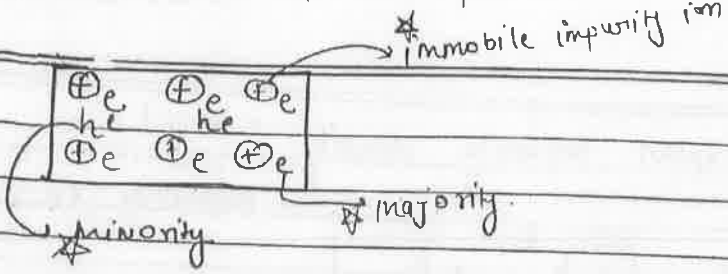
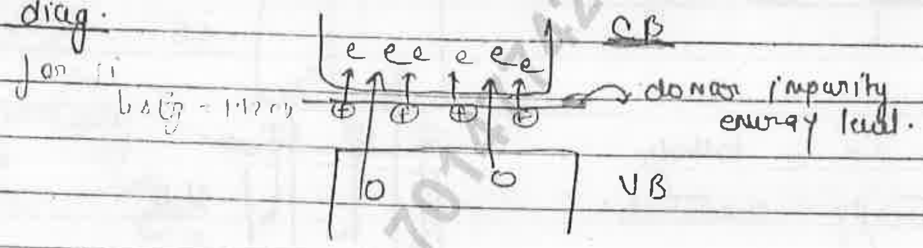
Representation of N-type S.C. →



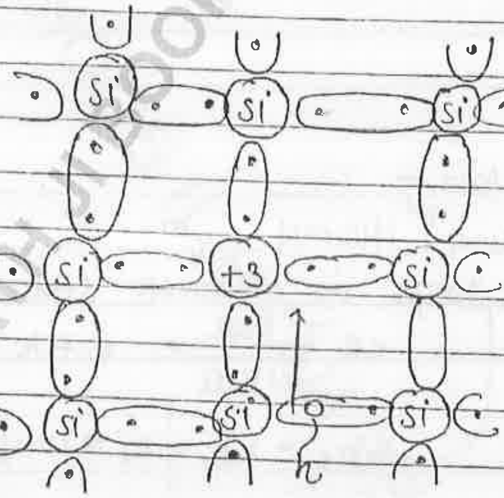

⇒ N-type SC is totally electrically neutral.



⇒ Energy level diag.




[ii] p-type S.C. ⇒



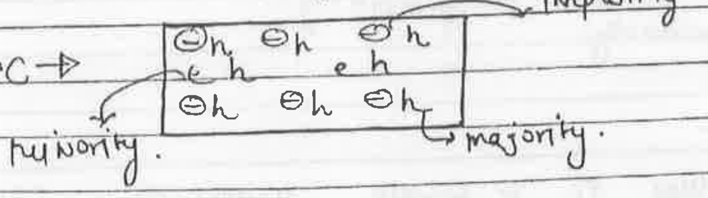

⇒ at room temp. impurity atom accept one bonded $e^-$ from crystal so these impurity are K/w as acceptor impurity

⇒ after accept one bonded $e^-$ impurity atom becomes immobile -ve ion.

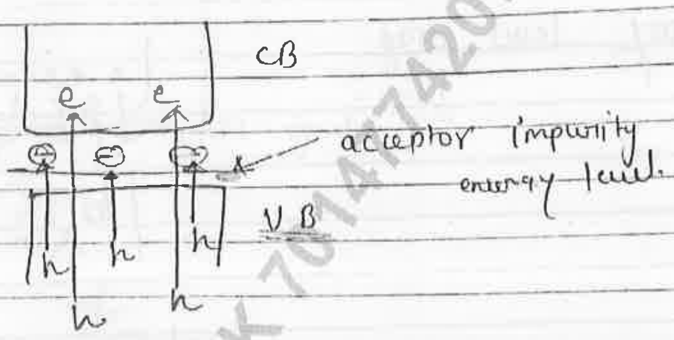
⇒ majority charge carrier ⇒ Hole
minority " " ⇒ $e^-$

⇒ Hole density ($n_h$) = acceptor impurity density ($N_A$)

Representation of P type S.C →




⇒ Energy level diag.




P-type S.C is totally electrically neutral.

17/12/16

Mass action law →

* it is based on thermal eq$^m$.

① * At, const temp. in intrinsic semiconductor

$$CB \underset{\text{const Rate}}{\overset{\text{const Rate}}{\rightleftharpoons}} e + h$$

→ $n_e = n_h = n_i = \text{const.}$

② in extrinsic S.C. (N- type) pentavalent

~~CB ⇌ e + h~~

$$C.B. \underset{\text{fast rate}}{\overset{\text{const. Rate}}{\rightleftharpoons}} \underline{e} + \underline{h}$$

covalent bond

so, extra $e^-$ int. e (due to impurity)

if p type int. then no. of h more than $e^-$

[3] MASS - ACTION LAW →

at const. temp → bcoz based on Thermal eqn.

before doping (intrinsic) (extrinsic) after doping

$n_e \times n_h = n_e' \times n_h'$

$n_i \times n_i = n_e' \times n_h'$

$$n_i^2 = n_e' \times n_h'$$ → used when → we have to find minority.

[4] EXTRINSIC

N-type

$n_e'$ = donor impurity density ($N_D$)

$$n_h' = \frac{n_i^2}{n_e'} = \frac{n_i^2}{N_D}$$

P-type

$n_h'$ = acceptor impurity density ($N_A$)

$$n_e' = \frac{n_i^2}{n_h'} = \frac{n_i^2}{N_A}$$

100%

imp point - At const. temp, when intrinsic S.C. convert into extrinsic S.C. then note only majority charge carrier ↑se but minority charge carrier also ↓se bcoz Rate of e⁻ hole recombination ↑se.

in Si → Al is added then → ...

100% Imp

Q→ At room temp Si atom density is $5\times10^{28}$ atoms/$m^3$ if As doped at 1PPM then calculate $e^-$ & hole conc

given $n_i = 1.5\times10^{16}\ m^{-3}$

$Si = 5\times10^{28}$

$n_i = 1.5\times10^{16}$

1PPM = 1 in $10^6$ Si atom | 1 atom = impurity

Si density $= 5\times10^{28}$ atm/$m^3$

for 1 si atom

impurity density $= \frac{1}{10^6}\times5\times10^{28}$

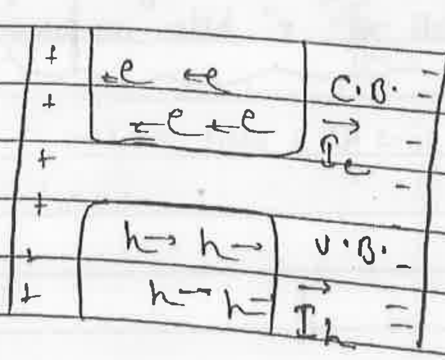
$= 5\times10^{22}$ atm $m^{-3}$

As → pentavalent ⇒ donar impurity.

$n_{e^-} = N_D = 5\times10^{22}\ m^{-3}$

$n_h = \frac{n_i^2}{n_e} = \frac{(1.5\times10^{16})^2}{5\times10^{22}} = 4.5\times10^{9}\ m^{-3}$

Electric conduction in semiconductor →




$$I = I_e + I_h$$

| | INTRINSIC $n_e = n_h = n_i$ | N-type ($n_e >>> n_h$) | P-type ($n_h >>> n_e$) |
|---|---|---|---|
| ① $\sigma = ne\mu$ conductivity | $\mu_e > \mu_h \Rightarrow \sigma_e > \sigma_h$ <br> $\sigma = \sigma_e + \sigma_h$ <br> $= n_e e \mu_e + n_h e \mu_h$ <br> $\boxed{\sigma = n_i e(\mu_e + \mu_h)}$ | $\sigma_e >> \sigma_h$ <br> $\sigma \simeq \sigma_e$ <br> $\boxed{\sigma = n_e e \mu_e = N_D e \mu_e}$ | $\sigma_h >> \sigma_e$ <br> $\sigma \simeq \sigma_h$ <br> $\boxed{\sigma = n_h e \mu_h = N_A e \mu_h}$ |
| ② $\rho = \frac{1}{\sigma}$ | $\rho = \frac{1}{n_i e(\mu_e + \mu_h)}$ | $\rho = \frac{1}{n_e e \mu_e}$ | $\rho = \frac{1}{n_h e \mu_h}$ |
| ③ $I = n_e A v_d$ <br> $= neA(\mu E)$ | $I = I_e + I_h$ <br> $I = n_i eA(v_{de} + v_{dh})$ | $I = I_e$ | $I = I_h$ |
| | $\mu_e > \mu_h \Rightarrow I_e > I_h$ | $I = 2I_e$ <br> $I > 2I_e$ <br> $I < 2I_e$ ✓ | $I = 2I_h$ <br> $I > 2I_h$ ✓ <br> $I < 2I_h$ |

Q– in N-type S.C. mobility of $e^-$ is $5000\ cm^2/V\text{-}s$ & its conductivity is $5\ \Omega\ cm^{-1}$. find impurity density.

$$\sigma = \sigma_e \Rightarrow n_e e \mu_e$$

$$N_D = n_e = \frac{\sigma}{e\mu_e} = \frac{5}{1.6 \times 10^{-19} \times 5000}$$

$$= 6.25 \times 10^{15}\ cm^{-3}$$

## P-N JUNCTION ⇒

When p-type & n-type S.C. are (atomically joint) together then p-n junction are formed.

During the junction formation two process are obtained —

(I) Diffusion
(II) Drift

### [1] Diffusion →

(I) Due to conc. gradient (majority) charge carriers are diffused from high conc. to low conc. means h $\overset{diffuse}{\Rightarrow}$ p to n &
e $\underset{diffuse}{\Rightarrow}$ n → p.

(II) Dir^n of diff. current p → n.
Near the junction these charge carriers are recombine & disappear, so at junction a region produced which have only immobile impurity ions k/w as DEPLETION LAYER.

(III) In depletion layer, due to ⊕ immobile ions N-side become high pot. & due to ⊖ immobile ions p-side become at low pot. & due to pot. diff. an internal E.F. produce in depletion layer & its dir^n is N → P.

produce internal E.F. (in depletion layer) oppose the diffusion process, so diffusion current ↓se.

### [2] DRIFT

(I) Due to thermal energy (when minority) charge carrier enter in depletion layer then internal E.F. drift the minority charge carriers.

Hole drift → n − p
$e^-$ drift → P → N.

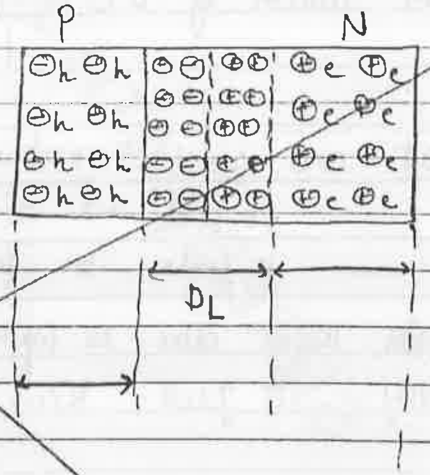
(I) Dirⁿ of drift current N ⟶ P
(II) Drift current mainly depend on temp.

JUNCTION FORMATION – (I) initially diffusion current large & drift current negligible. due to diffusion
(II) During the junction formation width of depletion layer ↑se.
(III) pot. diff. across " ↑se.
(IV) strength of internal E.F ↑se, so diffusion current rapidly ↓se & drift current highly ↑se.

(V) At equillibrium, |I diffusion| = |I drift|
P ⟶ N    N ⟶ P

Net current passing from jun. = I diff + I drift
= 0 & we say junc formⁿ is complete.

20-12-16



Electric field only act in depletion layer.

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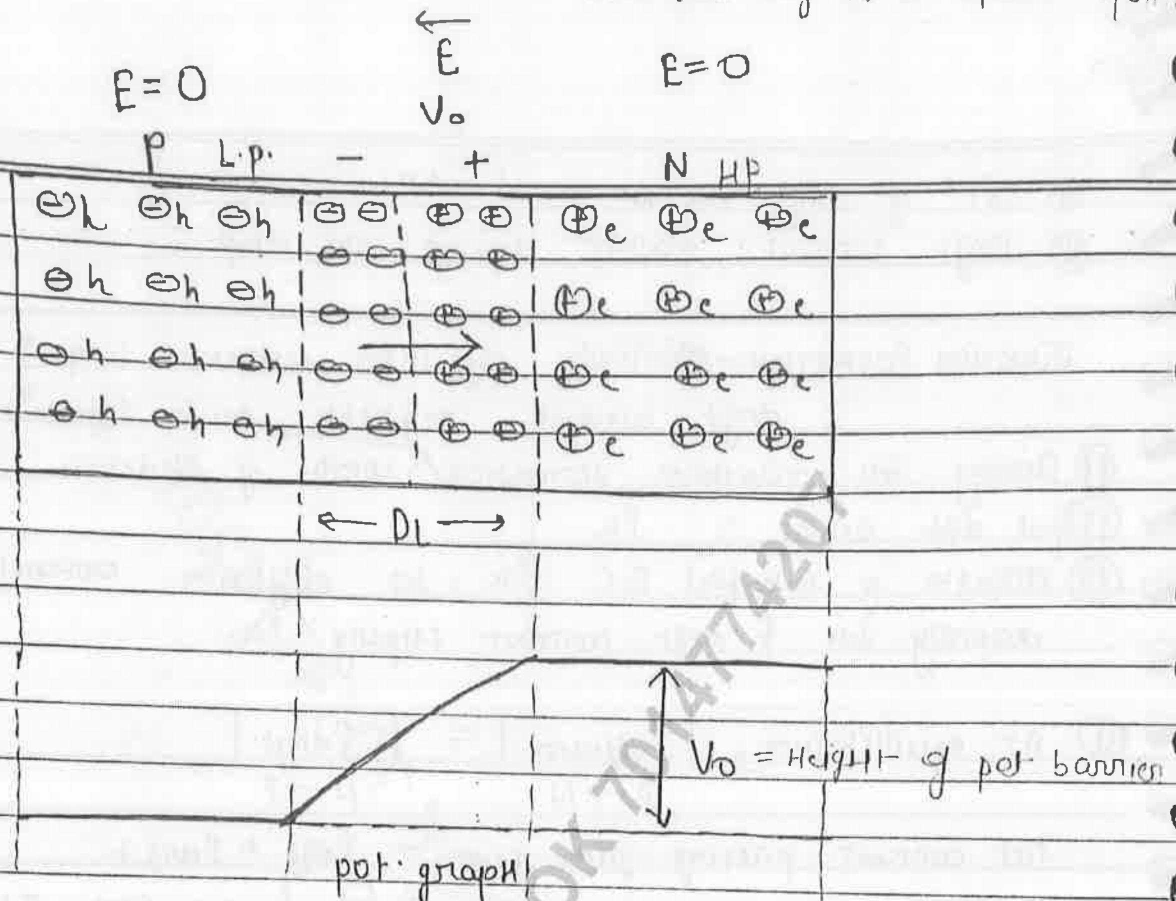



(I) At equilibrium width of D.L. = $\frac{1}{10}$ μm = $10^{-7}$ m = 0.1 μm

(II) Barrier pot or contact potential ($V_0$) ⇒

N side → High pot.

P side → low pot.

At eqᵐ ⇒ for Si = 0.7V, Ge = 0.3V

● In depletion layer due to immobile impurity ion, produce pot diff. at Jun. k/w as Barrier pot.

(IV) Barrier pot depend on doping & temp. & type of S.C. ($\Delta E_g$)

(V) barrier voltage cannot be measure by voltmeter bcoz at eqᵐ Net current passing from Junct is zero.

IN D.L. → internal E.F. (motion of
↳ oppose → majority charge carrier
& ↳ support → minority " "

⇒ In depletion layer produce internal E.F. oppose the motion of majority charge carrier & support motion of minority charge carrier.

for Si $E_{avg} = \frac{V_0}{d} = \frac{0.7}{10^{-7}} = 7 \times 10^{6}$ V/m

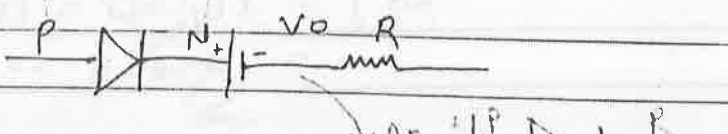
Ge $E_{avg} = \frac{V_0}{d} = \frac{0.3}{10^{-7}} = 3 \times 10^{6}$ V/m.

⇒ At middle of depletion layer intensity of E.F is max.

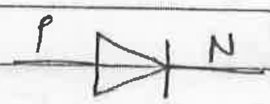
⇒ width of depletion layer $\alpha \frac{1}{\sqrt{\text{doping}}}$ → MTR.

temp., 10(3) & " " barrier voltage.

⇒ SYMBOL OF P-N JUNCTION
(I) real
(II) ideal

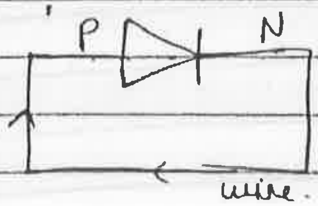



Diode → A PN junction with metallic contact k/a as diode (PN junction)




PN junction also k/a as diode.

Q →
I = 0




wire → Net current ⇒ 0
because battery is not connected

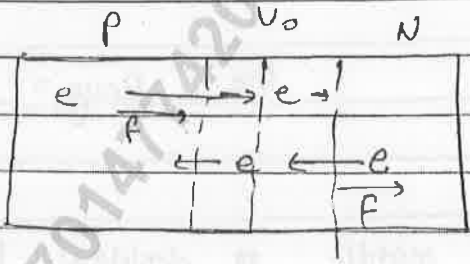
Que- In a p-N Juction barrier voltage ($V_0$) is 0.5 V when an $e^-$ Having KE 0.8 eV cross the D.L then its KE will be.

(I) When $e^-$ movin move from p side & enter in N side.

(II) When $e^-$ move N side & enter in p-side.

(I) $e^-$ p ⟶ N (minority)

$$KE_f = KE_i + W$$
$$= KE_i + qV_0$$
$$= 0.8\,eV + 0.5\,eV$$
$$= 1.3\,eV$$

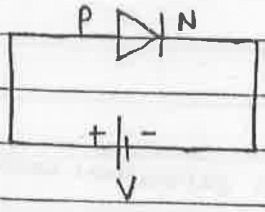
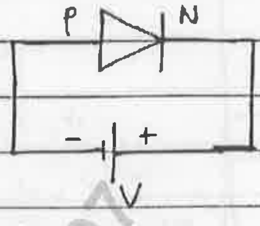
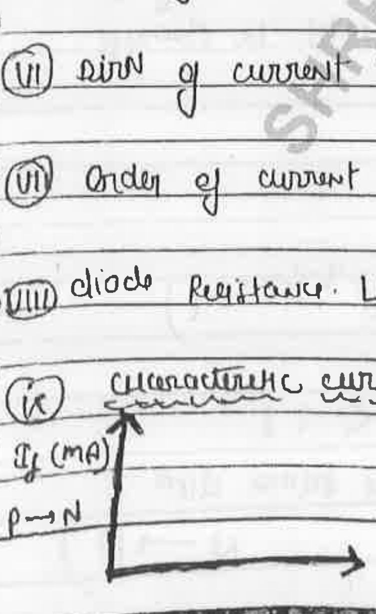



(II) N ⟶ p (majority)

$$KE_f = KE_i - W = KE_i - qV_0$$
$$= 0.8\,eV - 0.5\,eV = 0.3\,eV$$

BIASING OF DIODE ⟹ connecting external battery with diode k/a as Biasing.

[1] Forward Reverse (ON N.P.)

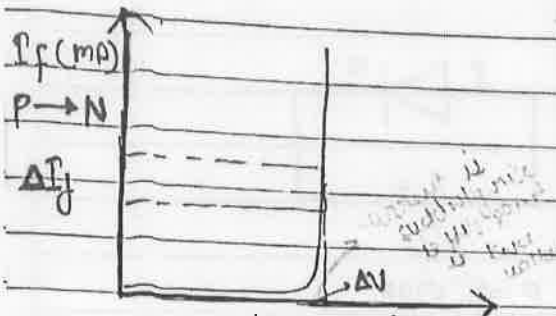
| FORWARD BIAS (F.B.) | REVERSE BIAS (R.B.). |
|---|---|
|   in barrier<br>N → High pot<br>P → low pot |   |
| P ⇒ High pot<br>N ⇒ low pot | P ⇒ ⊖ve<br>N ⇒ ⊕ve |
| (I) external battery repel the majority charge carrier move toward the junction, so width of D.L. ↓se. | (I) external battery attract the majority charge carrier away the junctio so width of D.L. ↑se. |
| (II) Barrier voltage ↓se. $(V_0 - V)$ | (II) Barrier voltage ↑se $(V_0 + V)$ |
| (III) strength of internal E.F. ↓se. | (III) strength of internal E.F. ↑se. |
| (IV) $\lvert I_{diffusion}\rvert > \lvert I_{drift}\rvert$ | (IV) $I_{diff} < I_{drift}$ |
| (V) current flow mainly due to majority charge carrier. | (V) current flow mainly due to minority charge carrier |
| (VI) dirn of current P → N | (VI) dirn of current N → P |
| (VII) Order of current High (mA) | (VII) Order of current very low, in Ge – μA, in Si – nA due to FED. |
| (VIII) diode Resistance Low (100 Ω) | (VIII) Junction resistance High ($10^6$ Ω) |
| (IX) characteristic curve ⇒   | |

* Reverse current does not depend on Reverse bias voltage. it depend on temp & Nature of S.C. material

$I_{net} = I_{diff} + I_{drift}$
P → N    N → P

* Si diode is more better than Ge b/o 2 (Forbidden energy gap) $\Delta E_g$.
~~reverse current in Si is less than Ge~~ reverse current in Si is less than Ge

## Forward bias (F.B)




Knee voltage $V_f$
cut in voltage
for Si → 0.7 V
Ge → 0.3 V

Resistance in F.B.

$$R_{FB} = \frac{\Delta V_f}{\Delta I_f} = \frac{1}{\text{slope}}$$

B voltage ... by ... ..... (?)

**Relation b/w I & V in F.B.**

$$I \propto e^V$$

Deriv.

$$I = I_0 \left(e^{qV/KT} - 1\right)$$

Here $I_0$ = reverse saturation current (const)

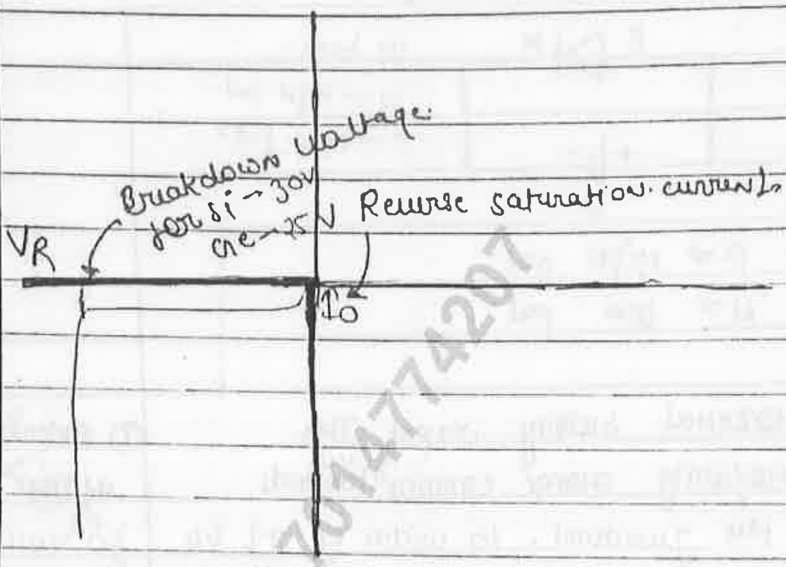
in FB $e^{qV/KT} >>> 1$

$$I \simeq I_0 e^{qV/KT}$$

$$I \propto e^V$$

Diode
(A non-ohmic device)

## Reverse bias (R.B)




At high reverse bias voltage large amount of cov. bond also break in dep. layer due to external voltage. so reverse current suddenly ↑se this phenomenon k/w as breakdown.

breakdown region of in reverse bias, due to excess of charge carrier Diode will be damage.

**Relation b/w I & V in R.B.**

$$I = I_0 \left(e^{-qV/KT} - 1\right)$$

$$e^{-qV/KT} << 1$$

$$I \simeq -I_0$$ ((−) we show dirn N → P)

Diode is a device which allows unidirectional current p to n when diode is in forward bias.

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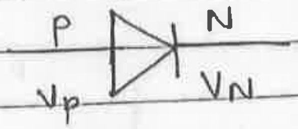
## FWD BIASING OF DIODE →

① 

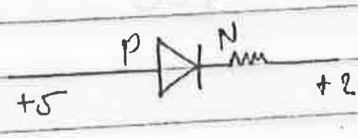

$V_p - V_N = \oplus ve \Rightarrow F.B.$

$V_p - V_N = \ominus ve \Rightarrow R.B.$

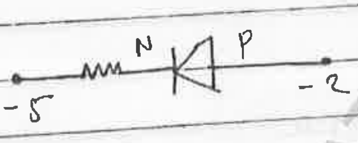
$V_p - V_N = zero \Rightarrow Unbias.$

imp

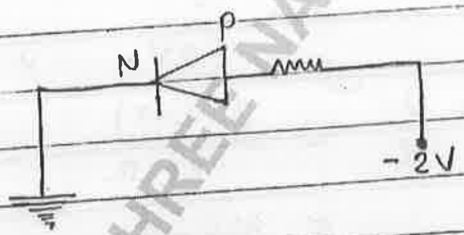
## Q → FWD BIASING OF DIODE →

① 

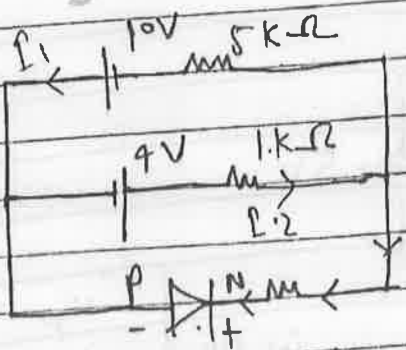

F.B.

② 


F.B.

③ 


R.B.

④ imp 


$I_1 = \frac{10}{5K\Omega} = 2mA$

$I_2 > I_1$

⇒ 4V battery effective

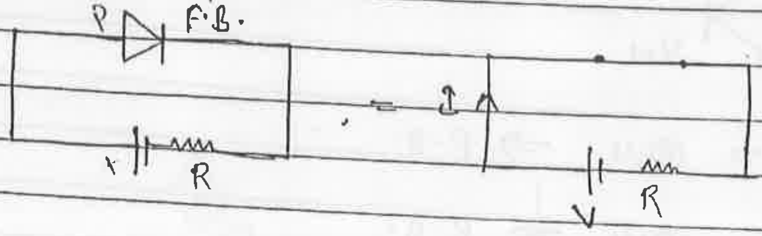
$I_2 = \frac{4}{1K\Omega} = 4mA$

R.B.

P with ⊖ [illegible] then F.B.
N with [illegible]

For ideal diode –

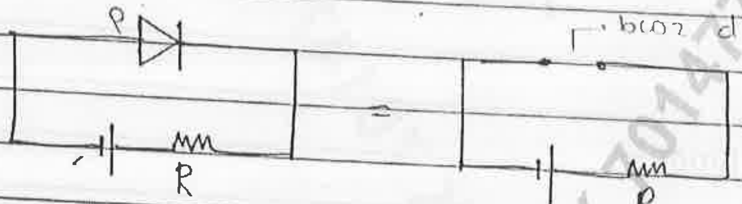
(I) IN F.B. diode $R = 0$




P with ⊕ so F.B.

$I = \frac{V}{R}$

(II) IN R.B. diode $R = \infty$



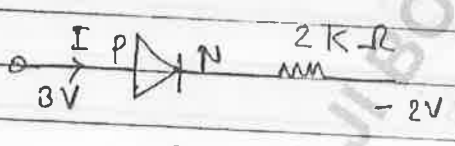

∵ b(o)z diode does not allow current

P with ⊖, so R.B.

$I = 0$

NEET)

Q. Find I




F.B.

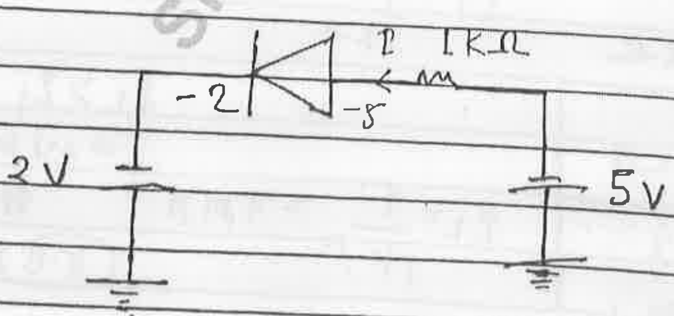
⇓


High → low pot.

$I = \frac{V \rightarrow \text{pot diff}}{R} = \frac{3-(-2)}{2k\Omega}$

$= 2.5 \text{ mA}$

Qu –




P with ⊖ so R.V.

Find I = ?

↳ diode is IN RB

$V_P - V_N$ (R.B.)

$-5-(-2)$

$= -3V \Rightarrow$ R.B.

∴ $I = 0$

(1 mA) K Ω $\xrightarrow{\times 10^3}$ Ω

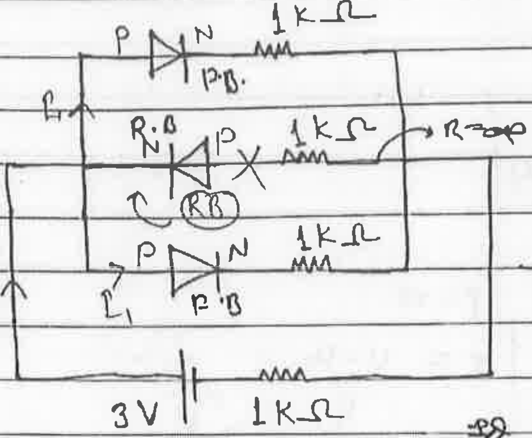
$= \frac{3}{(1+0.5)\times 10^3} = \frac{3}{1.5\times 10^3}$

$= 2mA$

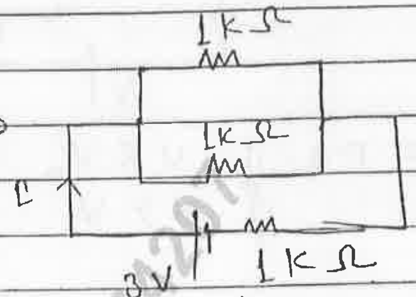
Find I = ?

Q10 →

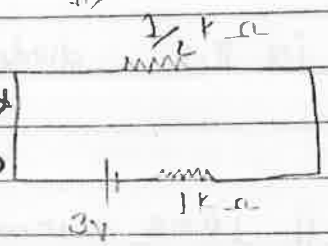
$I = \frac{V}{R} = \frac{3}{1.5\ \Omega} = 2mA$







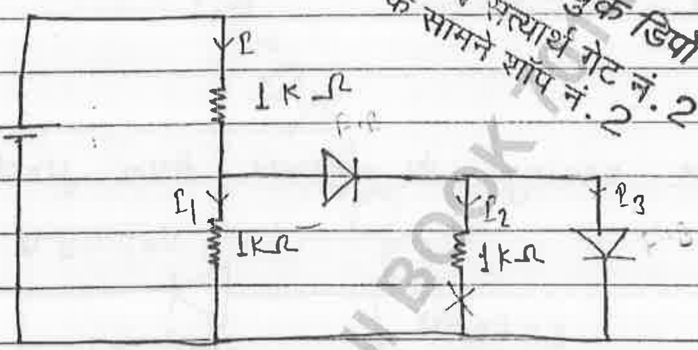






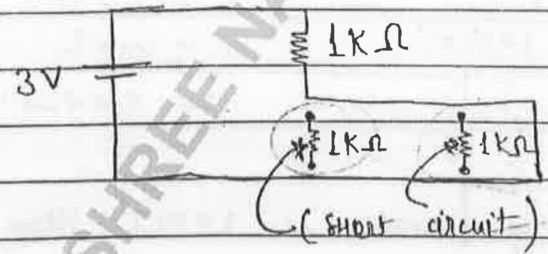


Q10 –





Find $I_1$, $I_2$, $I_3$ & I

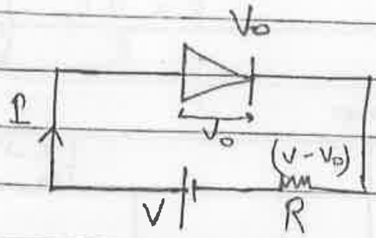




$I_3 = I = \frac{V}{1K\Omega} = 3mA$

$I_2 = I_1 = 0$

## Real diode →

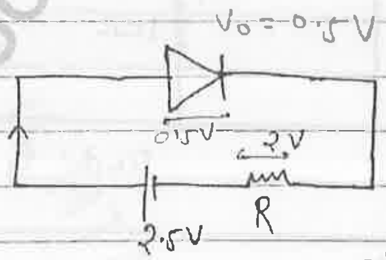



(1) in F.B. if $V < V_0 \Rightarrow I = 0$

if $V > V_0 \Rightarrow I = \frac{V - V_0}{R}$

(2) in R.B. diode, $R = \infty$

Q. if 10 mA current passing in circuit then find R.




$R = \frac{V - V_0}{I}$

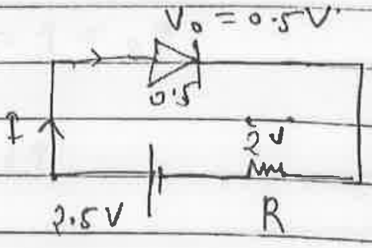
$= \frac{2.5 - 0.5}{(10 \times 10^{-3})} = \frac{2}{10 \times 10^{-3}}$

$R = 200 \Omega$

$= \frac{0.2 \times 10^{-2}}{2 \times 10^{-2}}$

$= 200 \Omega$

Q- if max. power rating of diode is 10 mJ then find min value of resistance R.




$P = I \cdot V_0$

$P = \frac{V^2}{R}$

$R = \frac{V^2}{P}$

$P_{max} = I_{max} \cdot V_0$

$10 \times 10^{-3} = I_{max} \times 0.5$

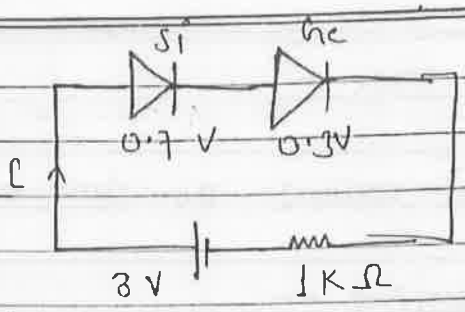
$I_{max} = 20 mA$

$R_{min} = \frac{V - V_0}{I_{max}} = \left(\frac{2.5 - 0.5}{20 \times 10^{-3}}\right) = 100 \Omega$

2/

Que -

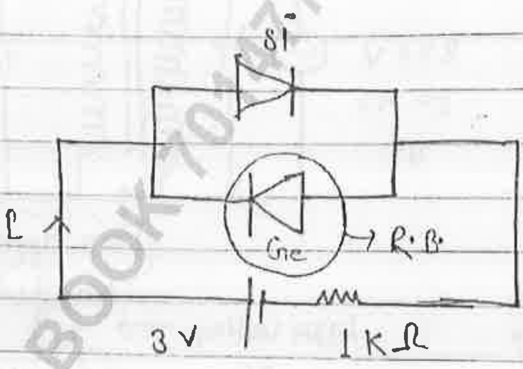
$I = ?$




$$I = \frac{3-(0.7+0.3)}{1\times10^{-3}}$$

$I = 2\,mA$

Que -

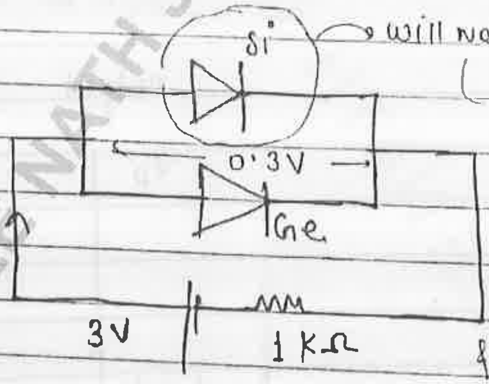



$I = ?$

$$I = \frac{3-0.7}{1\,K\Omega}$$

$= 2.3\,mA$

Que 2




Si → will not conduct ($\because V_0 = 0.7$)

$I = ?$

both diode in ∥ & we not conduct first in ∥, voltage same

$$I = \frac{3-0.3}{1\times10^{3}}$$

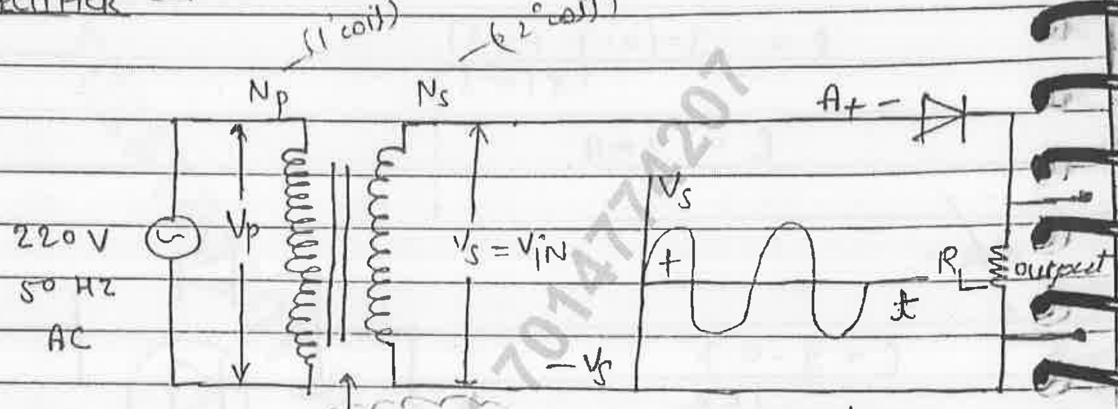
$= 2.7\,mA$

09/02/18

## Application of Diode —

① Rectifier → it convert AC into DC. k/w as Rectifier.

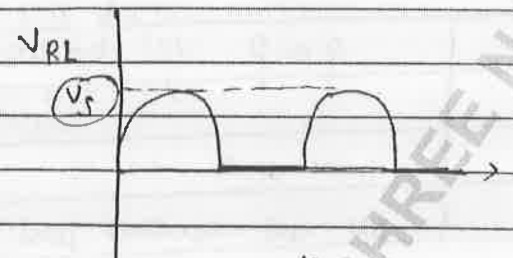
[A] Half wave Rectifier —




$\frac{V_s}{V_p} = \frac{N_s}{N_p}$   High voltage AC → Step down transformer → Low voltage AC

transform High volt. into low volt.

output across $R_L$

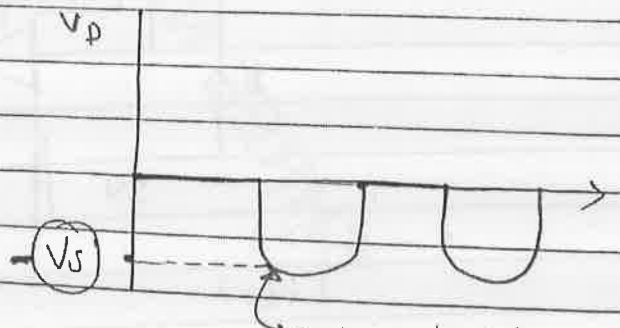



⇓

PULSATING DC

AC + DC

output across DIODE:

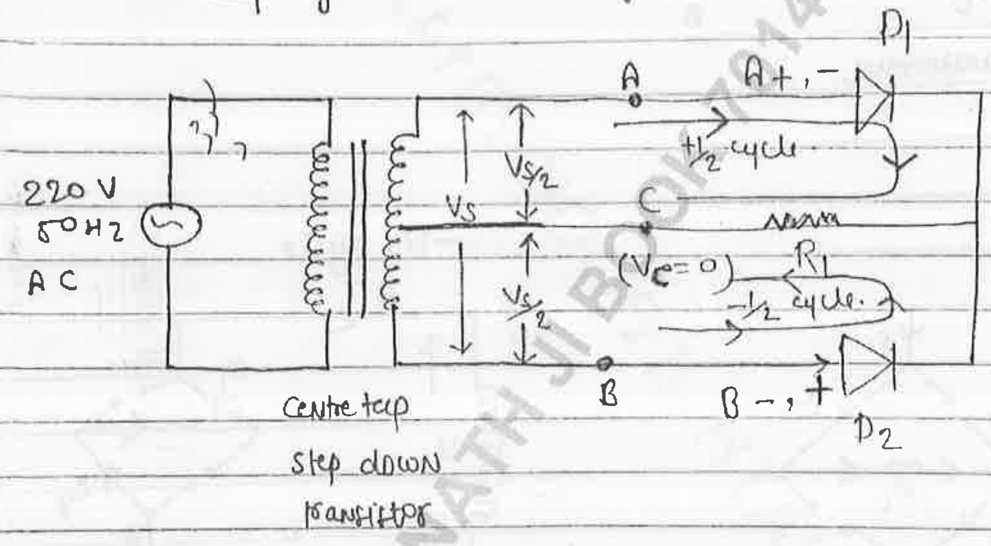


+ PEAK ~~INVERSE~~ voltage (PIV) :- it is max. voltage across
INVERSE diode in R.B.

$\boxed{PIV = V_s}$ = always.
secondry voltage

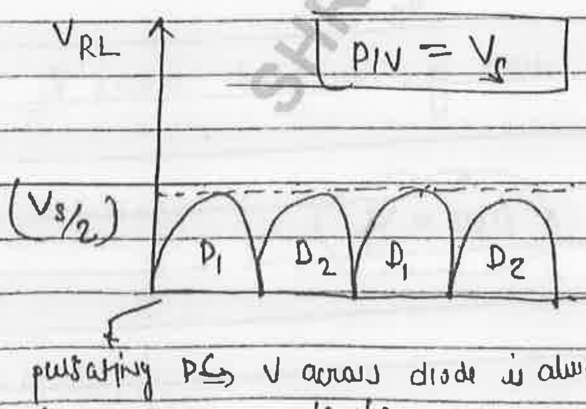
[2] Full wave Rectifier -

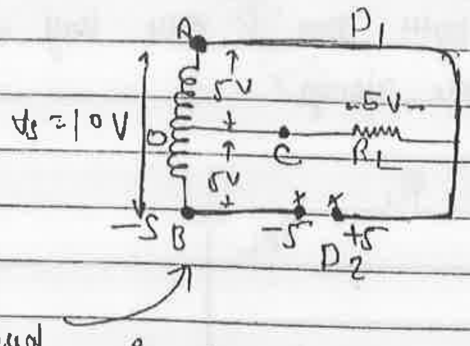
(A) Centre tap full wave rectifier




⇒ Across load resistance →

$\boxed{PIV = V_s}$



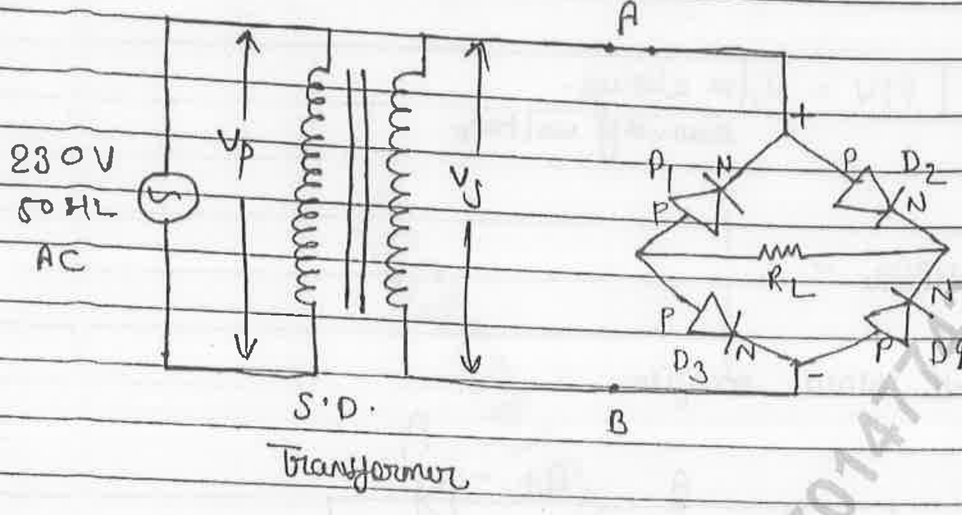



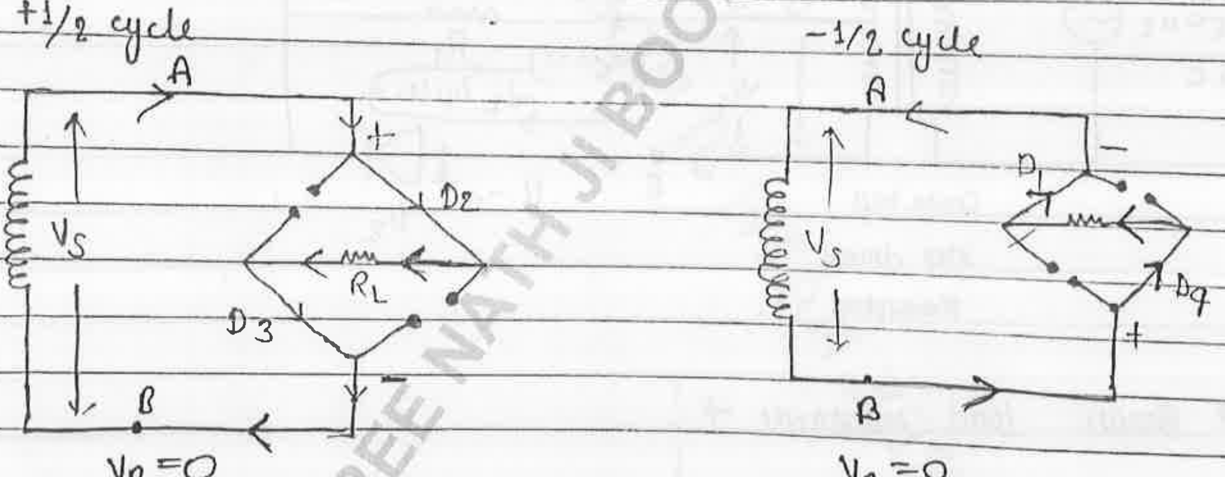

pulsating DC → V across diode is always equal to Vs
(AC+DC)

In case of centre tap F.W. rectifier, voltage across diode is double of the voltage across R1

Change of diode getting damaged are more.

[B] Bridge full wave rectifier

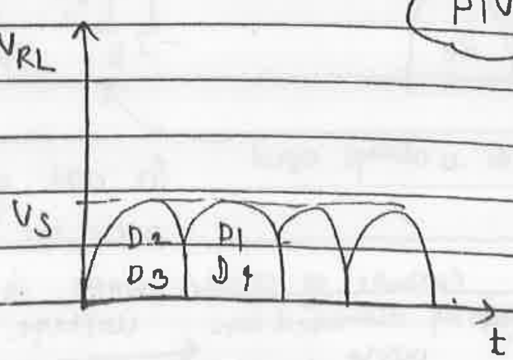



* in both one of one half cycle dirⁿ of current across $R_L$ is same always

* Across $R_L$

$PIV = V_s$



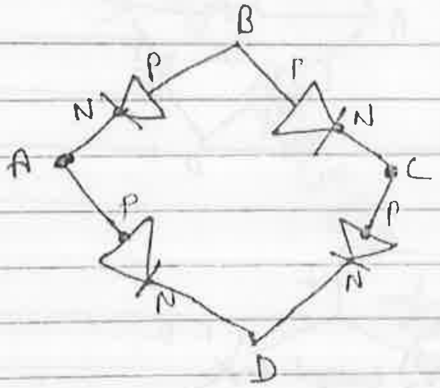
diode open (R.B.) $V = V_s$ (always)

## In Bridge full wave rectifier.

Input given → pt where P & N are connected

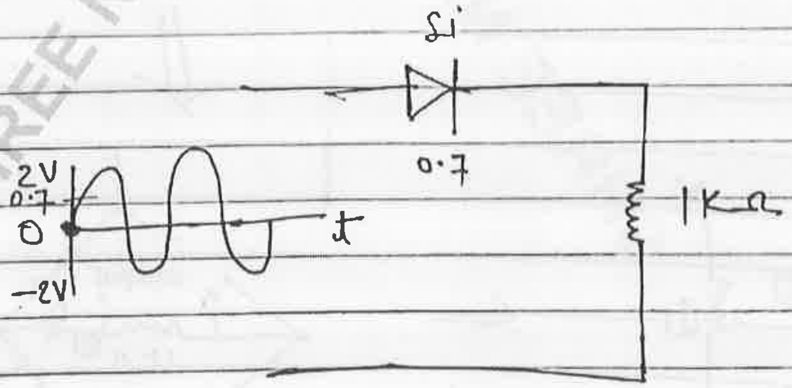
Output given → pt where P, P and N, N are connected
(if arrangement is interchanged then output will be zero)

Ques

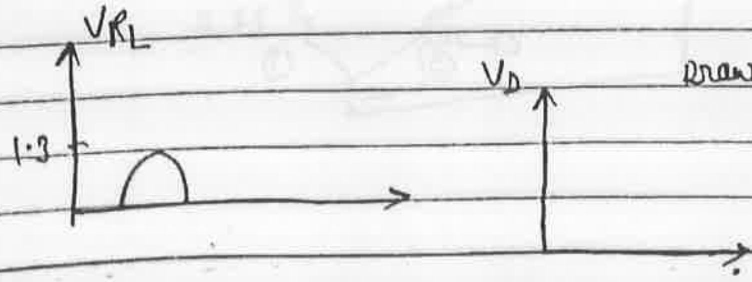



| |
|---|
| input → A, C |
| output → B, D |

Q. If given ckt work as full wave rectifier then input & output point will be ?




Sol^n :-




Draw o/p voltage across $R_L = 1\,k\Omega$ and diode

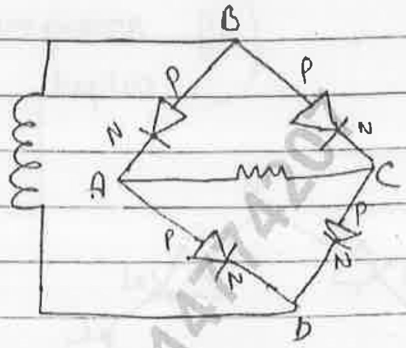
25/12/16

Que- given circuit work as a full wave rectifier then input & output terminal.

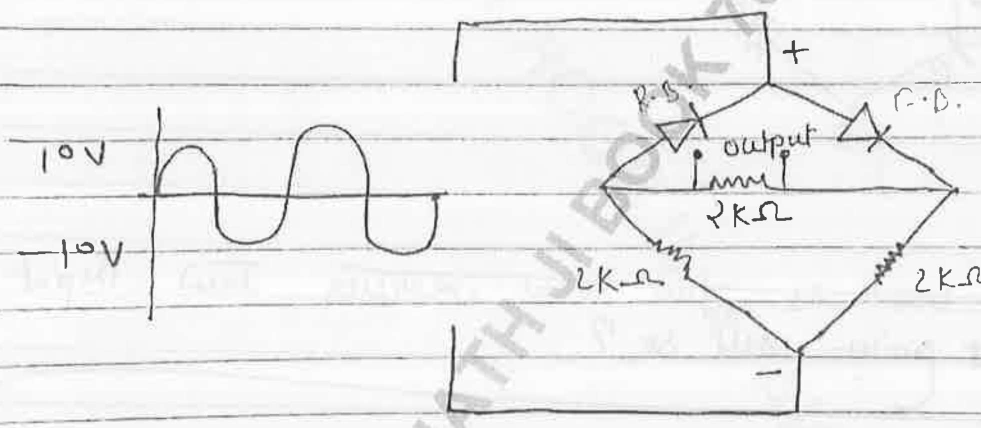
if input & output are interchanged then output will be?

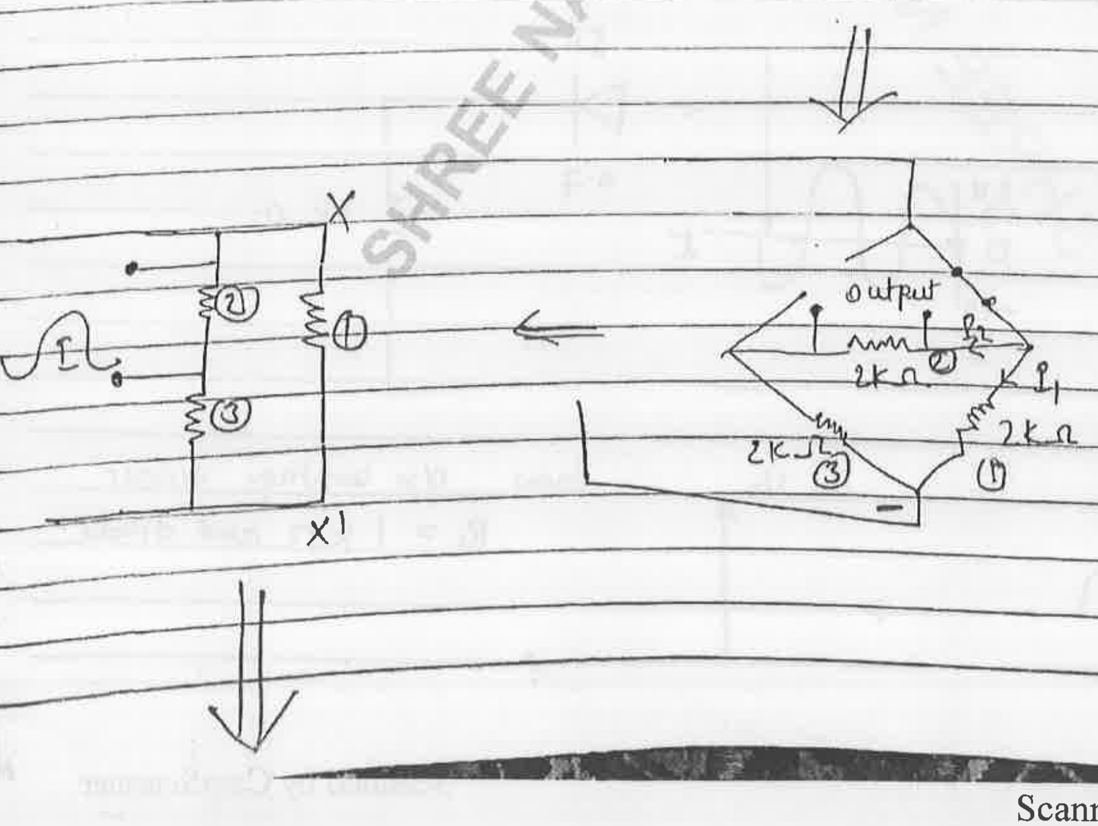
input → A, C

output → B, D

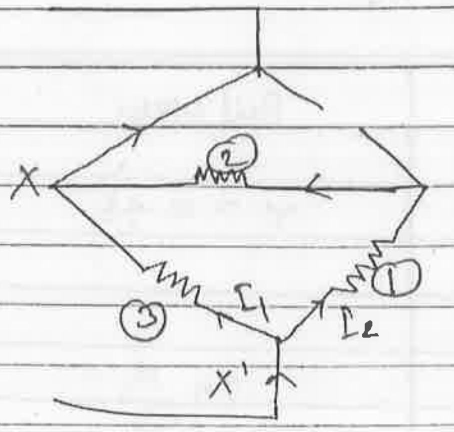


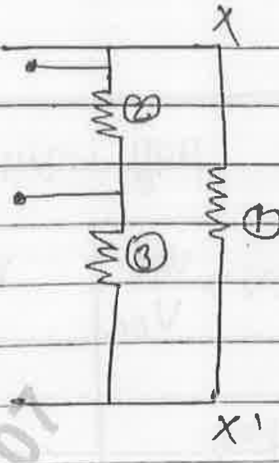

Que-

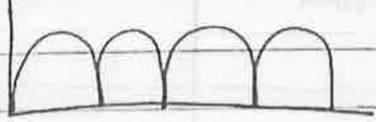


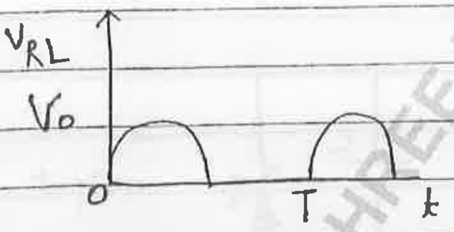
$-\frac{1}{2}$ cycle.



HALF WAVE RECTIFIER



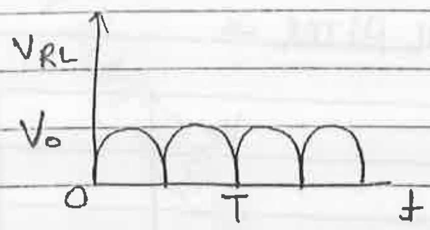

pulsating DC.

① $V_{rms} = \frac{V_0}{2}$ ($V_0$ → output voltage)

② ☆ $V_{DC} = \frac{V_0}{\pi}$

↓ (av. value) of output

FULL WAVE RECTIFIER




$V_{rms} = \frac{V_0}{\sqrt{2}}$

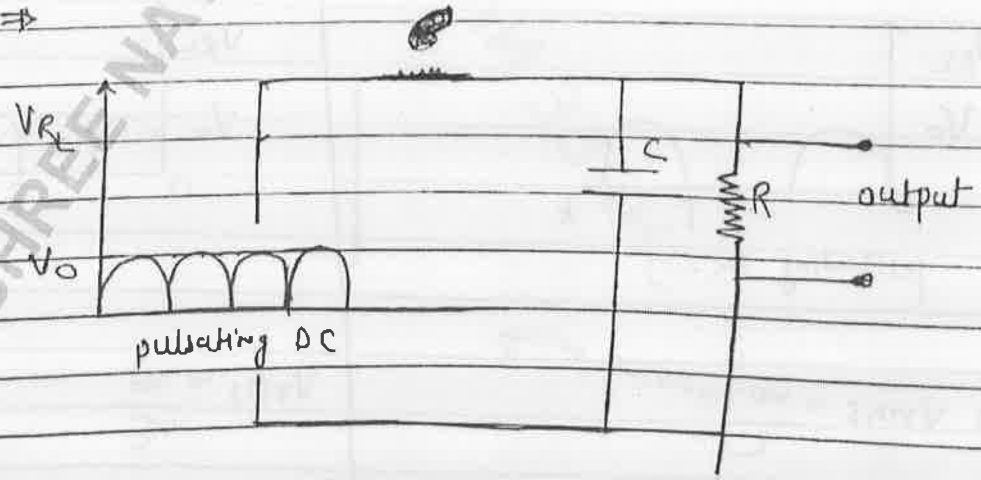
$V_{DC} = \frac{2V_0}{\pi}$

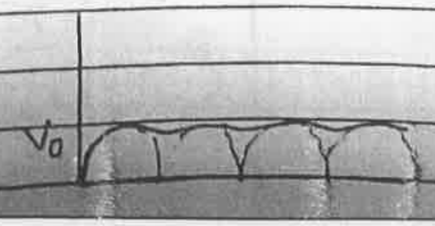
ripple factor ($\gamma$) min $\Rightarrow V_{DC}$ more

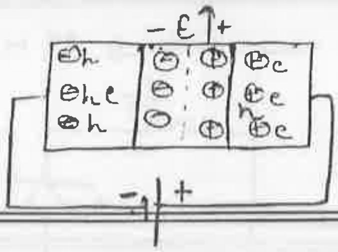
| | Half wave | Full wave |
|---|---|---|
| ③ ripple factor ($\gamma$) = $\frac{VAC}{V_{DC}}$ | $\gamma = 1.21$<br>$VAC > V_{DC}$ | $\gamma = 0.48$ |
| ★ ④ ripple freq.<br>input freq = n | n | 2n |
| ⑤ Efficiency ($\eta$) $\frac{output}{input}$ | $\eta_{max} = 40.6\%$. | $\eta_{max} = 81.2$ |

FILTER CIRCUIT ⇒ it convert pulsating DC into DC (reduce ripple).

① Capacitor filter ⇒





(i) IN capacitor filter, capacitor always connected ∥ to load resistance of rectifier circuit

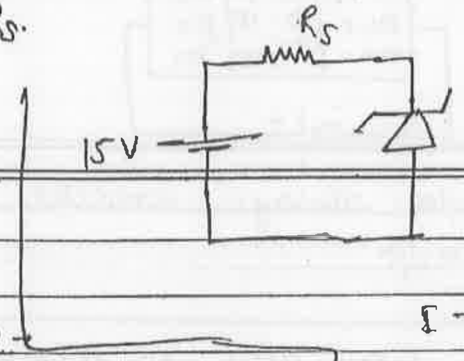
(ii) Here value of R & C taken HIGH so discharging time const. of capacitor $\tau = RC$ ← discharging time const of capacitor

(iii) Due to High value of time const. voltage across the capacitor approximate remain const. ($V_o$ is maintain)

Types of Breakdown –

| Zener Breakdown | Avalanche breakdown |
|---|---|
| (1) Here covalent bond of depl. layer are self break due to HIGH internal E.F. (Field emission) | (1) Here, covalent bond of DL are break due to collision of highly accelerated minority charge carrier |
| (2) Doping HIGH | (2) Doping low |
| (3) width of DL ↓ | (3) width of D.L. ↑se |
| (4) $\uparrow E = \frac{V_o}{d\downarrow} \simeq$ const | (4) $\downarrow E = \frac{V_o}{d\uparrow} \simeq$ const |
| (5) Diode does not permanently damage | (5) Diode permanently damage |

Q- If power produce in zener diode is 24 mW then find series resistance $R_S$.




$V_Z = 8V$

$P_Z = I_Z \times V_Z$

$24 \times 10^{-3} = I_Z \times 8$

$I_Z = 3 mA$

$I = \frac{V - V_Z}{R_S}$

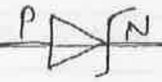
$R_S = \frac{V - V_Z}{I}$

$= \frac{15 - 8}{3 \times 10^{-3}} = \frac{7}{3} k\Omega$

SPECIAL DIODE

[1] ZENER DIODE

(i) Symbol –

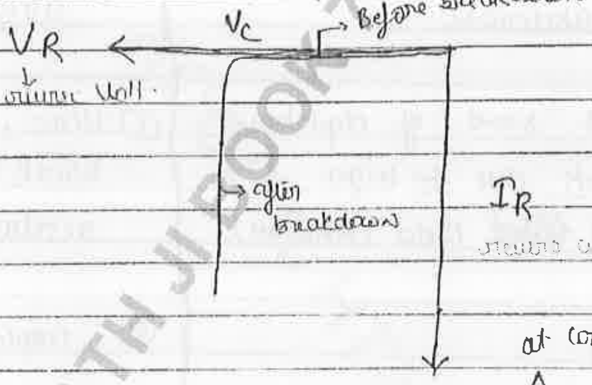



(ii) it always work in breakdown region of reverse bias.

(iii) Doping High, width of DL thin, Breakdown due to high E.F. $(10^6 V/m)$

(iv) characteristic curve →

V–I characteristic curve reverse volt.




(i) after breakdown, zener diode allow large current at const. voltage but voltage across zener diode remain const. & due to const. voltage zener diode used in voltage stabliser or voltage regulation.

Before breakdown zener diode behave as P-N junct.

{Voltage across zener remain constant}

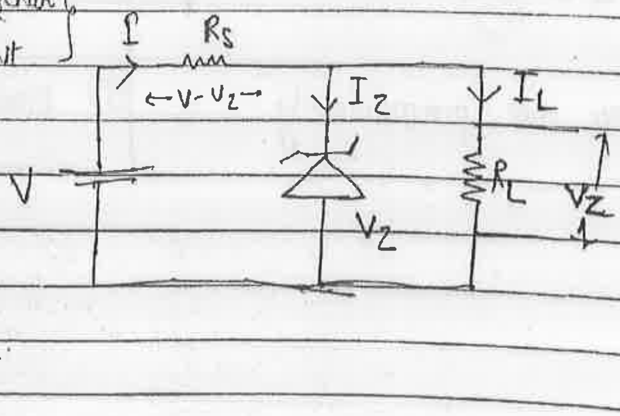
current across load circuit.

$I_L = \frac{V_Z}{R_L}$ → voltage of zener

$I = \frac{V - V_Z}{R_S}$

extra current across zener.

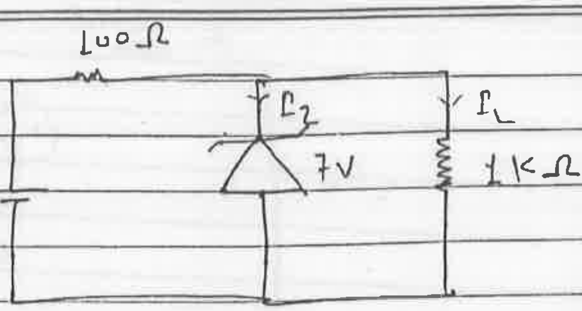
$I_Z = I - I_L$



$\frac{V}{\Omega} = A \longrightarrow mA$

$\boxed{\frac{V}{1K\Omega} = mA}$

Qn-




Find $I_z$

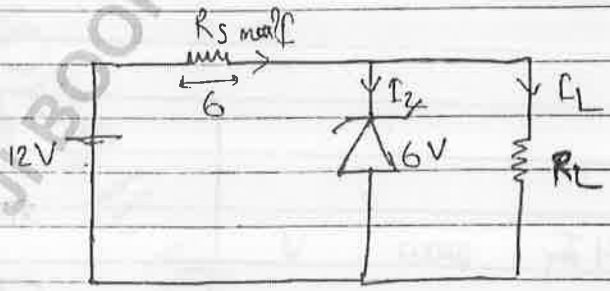
$I_L = \frac{V_z}{R_L} = \frac{7}{1K\Omega} = 7mA$

$I = \frac{V - V_z}{R_s} = \frac{10-7}{100} = \frac{3}{100} = 30mA$

$I_z = I - I_L = 23\ mA$

Aiims 2015 - q - 5-1 E-II

$R_s = ?$




$P_z = 2.4\ mW$

$P_z = V_z \times I_z$

$\Rightarrow 2.4 \times 10^{-3} = 6 \times I_z$

$I_z = 0.4\ mA$

for max. value of $R_s$
$I \longrightarrow min$

for $I_{min} \longrightarrow R_L$ taken very high & $I_L \simeq 0$

$I = I_z + I_L$
$= 0.4$

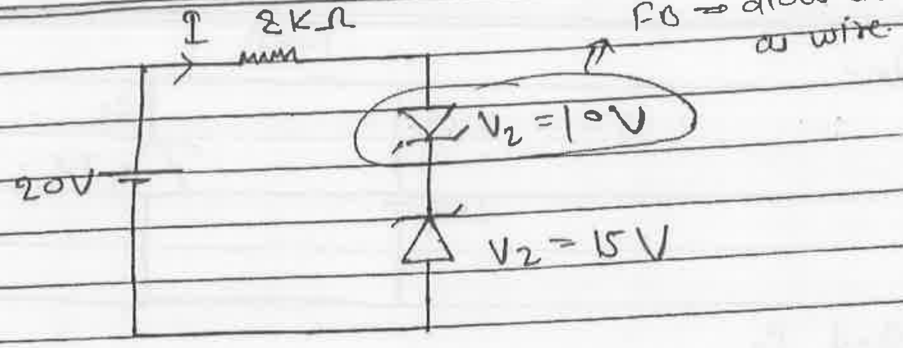
$R_s = \frac{V - V_z}{I} = \frac{12-6}{I_z}$

$I = I_z = 0.4\ mA$

$= \frac{6}{0.4\ mA}$

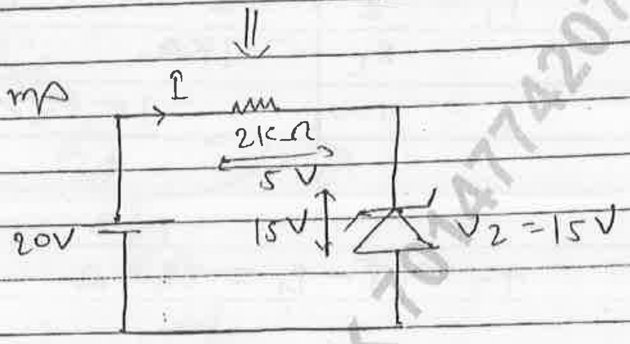
$= 15\ K\Omega$

Q- find I



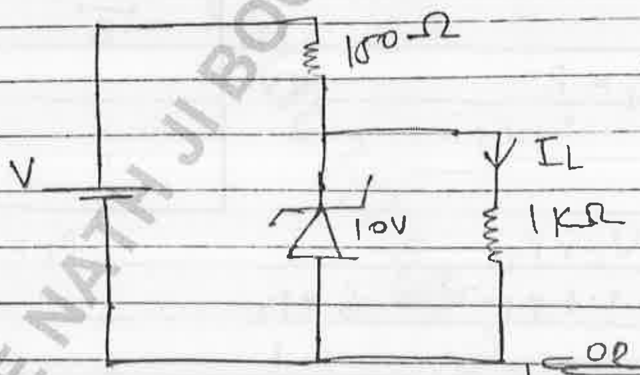

⇓

$$I = \frac{20-15}{2\times10^3} = 2.5\,mA$$




Q-

If $I_Z = 4 I_L$ then find V




OR

$$I_L = \frac{V_Z}{R_L} = \frac{10}{1K\Omega} = 10\,mA \qquad V = IR_s + V_Z$$

$$I_Z = 4I_L = 40\,mA$$

$$I = I_L + I_Z = 50\,mA$$

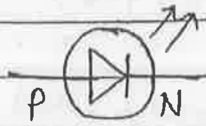
$$I = \frac{V-V_Z}{R_s} \rightarrow (50\times10^{-3}) = \frac{V-10}{100}$$

$$V = 17.5\,V$$

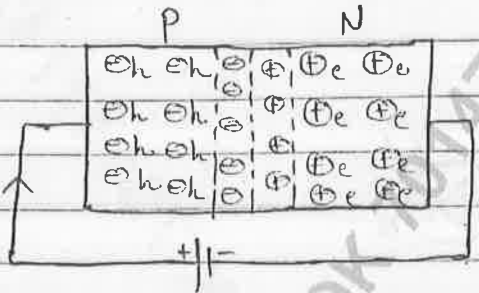
27/12/16

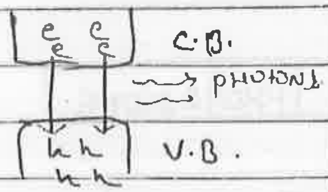
**Light emitting Diode - (LED)** ⇒ When current flow in LED then LED emmit light.

(1) Symbol →




[2] always use in F.B.
[3] Doping High
[4] width of DL Thin
[5] Working




(I) When current flow in LED then majority charge carrier are recombine near the junction.
For recombination $e^-$ move from C.B. to V.B. & release energy in form of photons.
due to these photon we obtain light.

(II) On ↑sing applied voltage, intensity of light → 1st ly increase become max. then ↓se, so LED operated low voltage. (approximate 2V) to 5V)

(III) energy of emmitted photon ≤ ΔEg
Energy of photon,

$$= \boxed{h\nu = \frac{hc}{\lambda} \leq \Delta E_g}$$

for light, λ ⇒ visible region (λ = 4000Å − 7800Å)

$\Delta E_g$ ⇒ 1.8 eV to 3 eV

so compound SC are used in LED
↳ $(Ga\ As_{1-x} P_x)$ ...

Intensity of emitted light $\propto$ no of emitted photons        U.V. → λ↑ → infrared (visible)

$\propto$ recombinations of majority charge carriers.

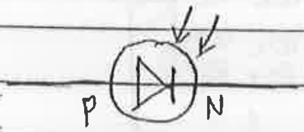
For red colour → $GaAs_{0.6}P_{0.4}$ ($\Delta E_g \simeq 1.9\,eV$)

Q- (AIIMS) if LED made by GaAs ($\Delta E_g = 1.6\,eV$) then λ of emitted light is in

ANS → infrared region. used in remote.

PHOTODIODE

① symbol →



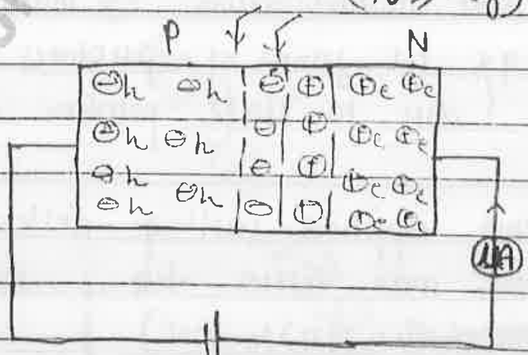

② it always work in R.B.

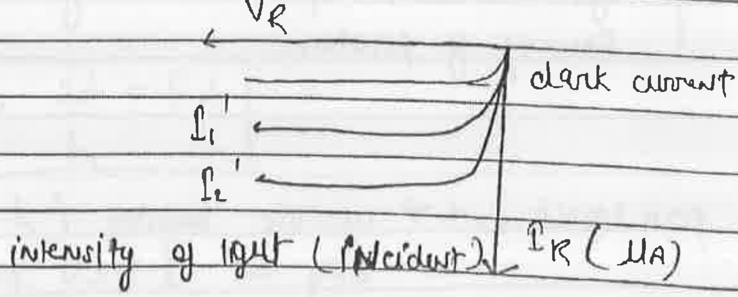
③ it use to detect light or intensity of light

** Photocurrent $\propto$ intensity of incident light

($h\nu \geq \Delta E_g$)

WORKING →




$I_2' > I_1'$

(4) photodiode detect light when

energy of incident photon $\geq \Delta E_g$

$$h\nu = \frac{hc}{\lambda} \geq \Delta E_g$$

$$\boxed{\lambda \leq \frac{hc}{\Delta E_g}}$$

$$\boxed{\lambda \leq \frac{12400\,Å}{\Delta E_g\,(eV)}}$$

NCERT

Ques. In a photodiode $\Delta E_g = 2.5$ eV then which wavelength of light can be detect by this photodiode.

(I) 4000 Å ✓ (II) 5000 Å

(III) 5800 Å (IV) 6200 Å

$$\lambda \leq \frac{12400}{2.5}$$

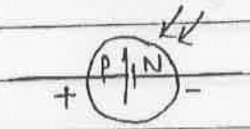
$$\lambda \leq 4960\,Å$$

⑥ solar cell construct in such a way so max. solar radiation incident on depletion layer.

SOLAR CELL ⇒

① it convert solar radiation into electrical energy.

② symbol –



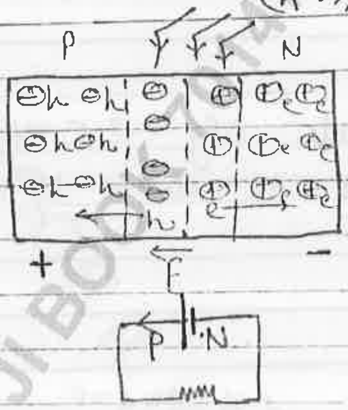

**

③ Always work in unbiased condition

④ ~~construct~~ construct by GaAs on Si. ($\Delta E_g \simeq 1.4 eV$)

⑤ WORKING PRINCIPLE same as PHOTODIODE.

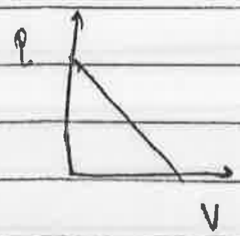
($h\nu \geq \Delta E_g$)

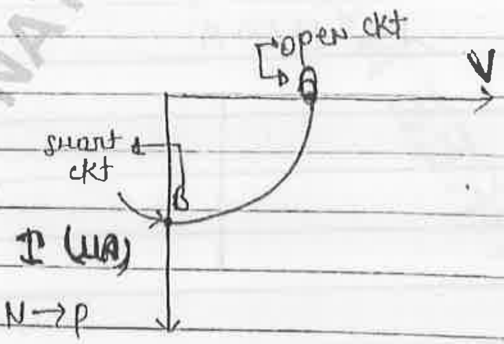



CHARACTERISTIC Graph of Solar cell →

T.P.D ⇒

$V = E - Ir$



Q: in a photodiode of $E_g = 2.8\,eV$ then which wavelength of light can be detect by the photodiode? (i) 4000Å (ii) 5000Å (iii) 5600Å (iv) 6200Å

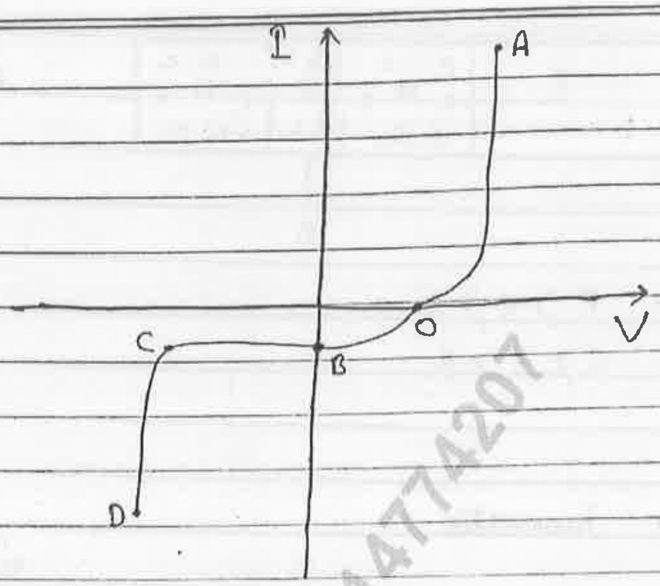
Ans →

OA = LED

OB = solar cell

BC = photodiode

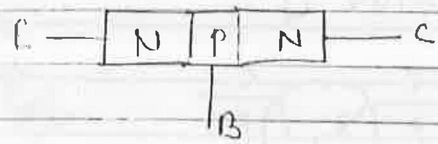
CD = zener diode.



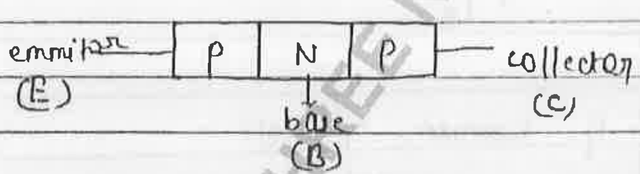

TRANSISTOR = Transfer + resistor

Types of Transistor →

① PNP transistor. ② NPN transistor




[1] PNP Transistor →

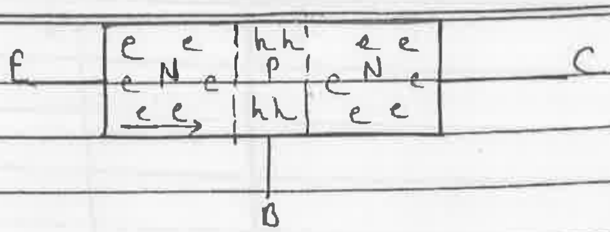



Emmiter – emmit charge carriers for current flowing in transistor.

Base – interconnect the emmitor & collector region

Collector → Collect the emmited charge carrier.

* NPN -

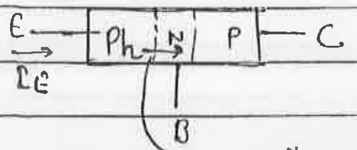



⇒ Doping → E > C > B

⇒ Size → C > E > B

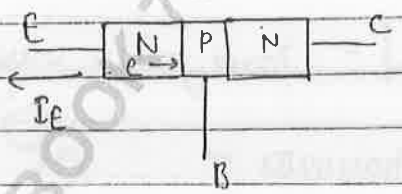
Symbol of Transistor -

(I) PNP

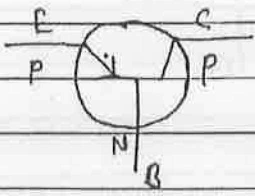


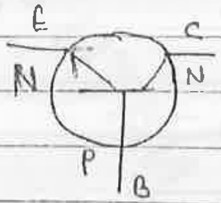

dir^n of current always P to N

(II) NPN




arrow - emitter
row - collector



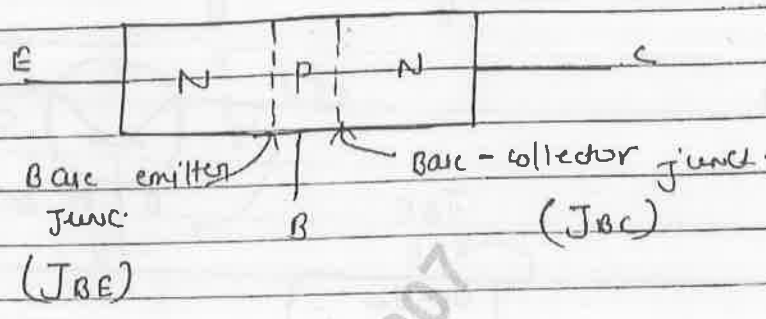

If current निकास
NPN.

If current प्रवेश
. PNP

⇒ Arrow on emmiter represent the dir^n of current in transistor or emmiter current dir^n.

imp

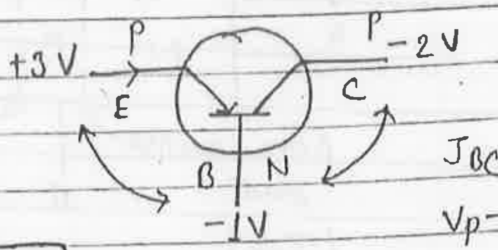
## Transistor Have Two Junction ⇒




| | JBE | JBC | Working mode of Transistor | Use of Transistor |
|---|---|---|---|---|
| ① | FB | FB | saturation mode | ON switch |
| ② | RB | RB | cut off mode | OFF switch |
| imp ③ | FB | RB | Active mode | Amplifier |
| ④ | RB | FB | inverse active mode. | X |

29/12/16

Que Find working mode of Transistor.

① 


$J_{BE}$ → FB

$V_p - V_N$
$+3 - (-1)$
$= +4$

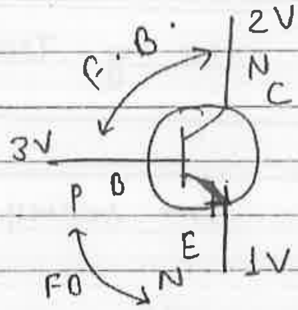
$J_{BC}$

$V_p - V_N$

$-2 - (-1) = -1$ → R.B.

↳ Active mod
↳ amplifier

$V_p - V_N$
$= 3 - 2$
$= 1$
$=$ FB

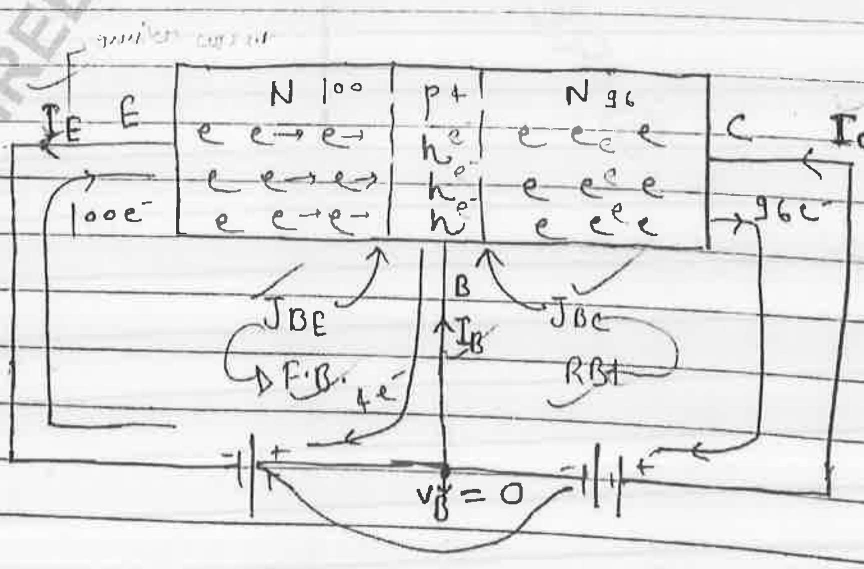
② 


$V_p - V_N$
$3 - 1$
$= 2$
FB

~~$V_B > V_P$~~

Both FB
↳ saturation mode
↳ switch on

Working of Transistor (Active mode) →



$\uparrow I_B$ 4% $I_E \uparrow$  $I_C = 96\% \uparrow$

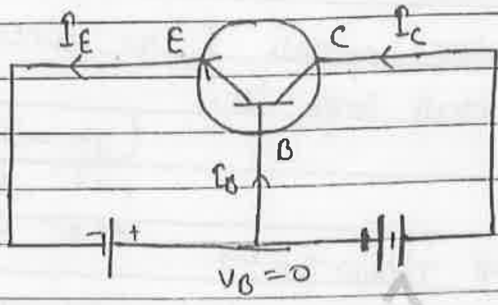
$I_E = I_B + I_C$

$100e^-$ $4e^-$ $96e^-$

$200e^-$ $8e^-$ $192e^-$

$\Delta I_B = 4e^-$ $\Delta I_C = 96e^-$

Symbolic representation




$I_E > I_C >> I_B$

$$I_E = I_B + I_C$$

[A]

(I) $I_E \Rightarrow$ current produce due to emmited charge carrier from emmitter.

(II) $I_B \Rightarrow$ current produce due to recombination of emmited charge carrier

(III) $I_C \Rightarrow$ current produce due to collected emmitted charge carriers.

[B] $I_E = I_B + I_C$

[C] Base current depend on doping & size of base region in base region if doping Ise then $I_B \uparrow$ & $I_C$ Ise.

[D] When Transistor operate (or) use then due to fix size & doping of base region %age recombination in base region remain constant.

(4%)

$\Rightarrow$ $I_E = I_B + I_C$

$100e^-$ $4e^-$ $96e^-$

$200e^-$ $8e^-$ $192e^-$

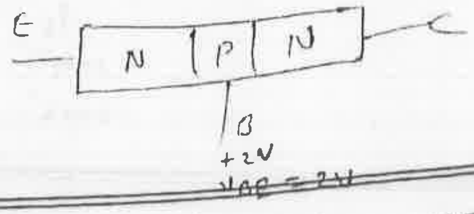
$\Delta I_B = 4e^-$ $\Delta I_C = 96e^-$

eg

↳ During the transistor manufacturing in base region doping Ise then $I_B$ Ise & $I_C$ Ise.

↳ when Transistor used then due to small change in base current large change produced in $I_C$.

eg




⇒ When transistor operate & base current ↑se then corresponding collector current large ↑se.

$$I_E = I_C + I_B$$

100e⁻ 4e⁻ 96e⁻

200e⁻ 8e⁻ 192e⁻

Configuration of Transistor →

When transistor use an amplifier then any one terminal of transistor become common in both input & output.

acc. to common terminal transistor have 3 confi:

① Common emmiter configuration (CE)

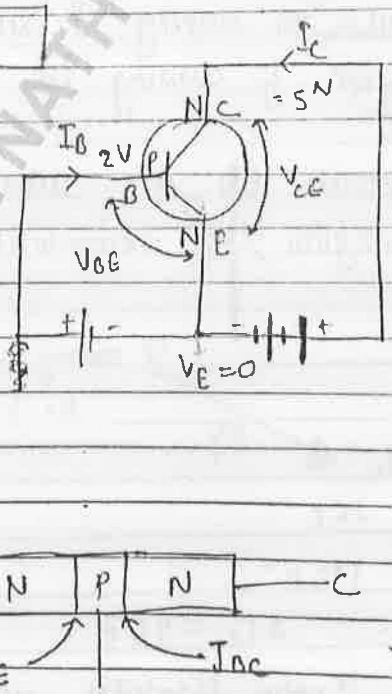
② Common base " (CB)

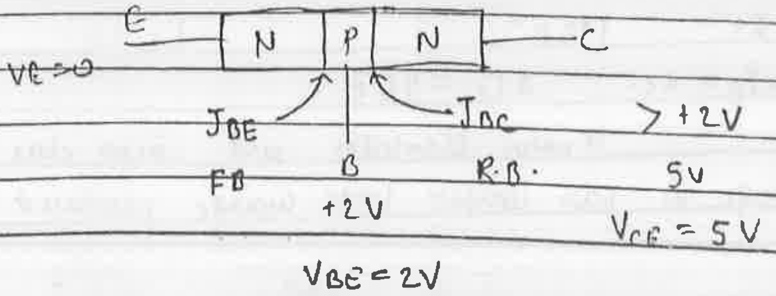
③ Common collector " (CC)

[1] Common emmiter configuration →

(a) Baising of transistor →

(i) NPN transistor →

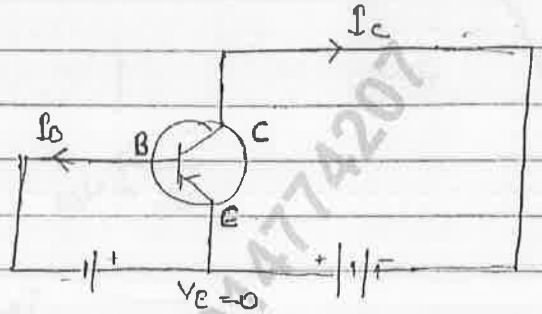


(i) When $V_{CE} > V_{BE}$ ($J_{BC} \rightarrow RB$) transistor is in active mode.

(ii) When $V_{CE} < V_{BE}$ ($J_{BC} \rightarrow FB$) transistor is in saturation mode

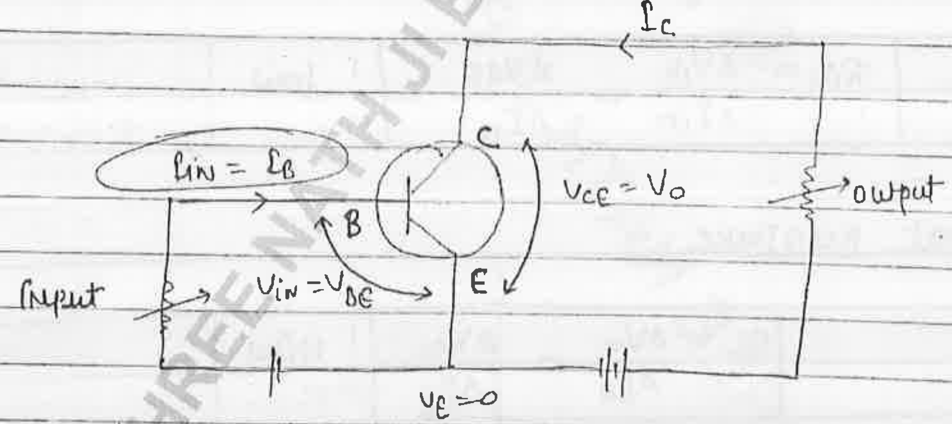
[ii] PNP -



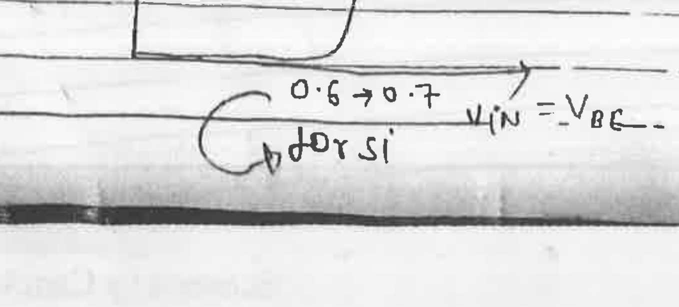



[2] Characteristic curve of C.E. Transistor -

$P_o > P_{in}$
$I_o > I_{in}$

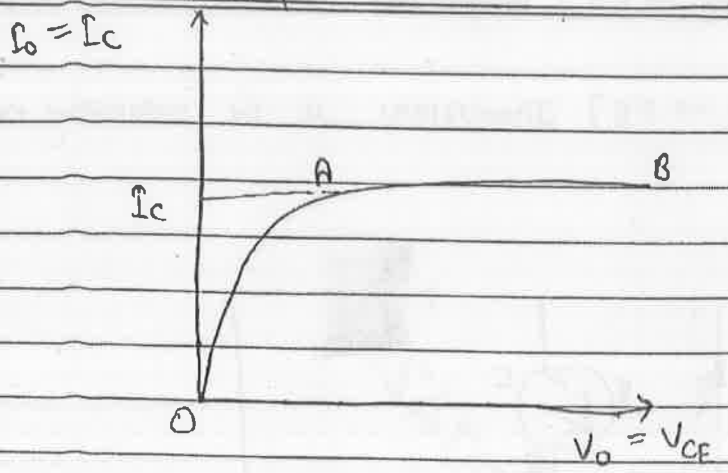



Input characteristic curve - Graph b/w input current & input voltage



Graph b/w output voltage &
" current.

output characteristic curve →




OA → saturation
AB → active.

OA → slope = High
$R_o$ = low

$J_{BC}$ → F.B. saturation mode

AB → slope = low
$J_{BC}$ → R.B.

$R_o$ = High
active mode

[i] Input Resistance of CE transistor →

$$R_{IN} = \frac{\Delta V_{in}}{\Delta I_{in}} = \frac{\Delta V_{BE}}{\Delta I_B} = \frac{1}{\text{slope}} \; \text{low}$$

slope → High
$R_{in}$ → low

[ii] Output Resistance –

$$R_o = \frac{\Delta V_o}{\Delta I_o} = \frac{\Delta V_{CE}}{\Delta I_C} = \frac{1}{\text{slope}} \; \text{High}$$

[iii] current gain or current amplification factor ($\beta$) →

** $$\beta = \frac{I_o}{I_{in}} = \frac{I_C}{I_B} = \frac{\Delta I_C}{\Delta I_B}$$

$\beta > 1$

(iv) voltage gain ($A_V$) →

$$A_V = \frac{\Delta V_o}{\Delta V_{iN}} = \frac{I_o R_o}{I_{iN} R_{iN}} = \beta \frac{R_o}{R_{iN}}$$

$\because \beta = \frac{I_o}{I_{iN}}$

$A_V > 1$

(v) power gain ($A_p$) →

$$A_p = \frac{P_o}{P_{iN}} = \beta^2 \frac{R_o}{R_{iN}} = \beta \cdot A_V = A_V^2 \frac{R_{iN}}{R_o}$$

($\frac{R_o}{R_{iN}}$ → $A_V$)

in C.E. transistor →

$\beta > 1$ . $A_V > 1$ ⟶ $A_p > 1$ (max)

so max power gain in C.E. transistor

(vi) Transconductance ($g_{iN}$)

$$g_{iN} = \frac{I_o}{V_{iN}} = \frac{I_C}{V_{BE}} = \frac{I_C}{I_B \cdot R_{iN}}$$

31/12/16

Q- In common emmiter transistor when voltage across the base emmiter terminal change by 0.04V ~~when~~ then base current change by 40 μA & collector current change by 2 mA if output resistance is 2 kΩ then find
(I) input resistance
(II) current gain
(III) voltage gain.

(I) $R_{in} = \frac{\Delta V_{BE}}{\Delta I_B} = \frac{0.04}{40\times10^{-6}} = 10^3\ \Omega = 1\text{ k}\Omega$

(II) $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{2\times10^{-3}}{40\times10^{-6}} = 50$

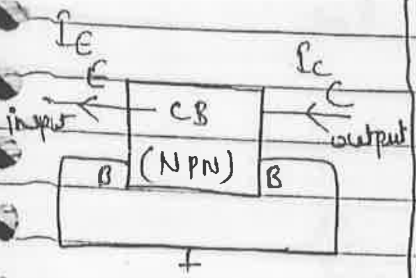
(III) $A_V = \beta \times \frac{R_o}{R_{in}} = 50 \times \frac{2\text{ k}\Omega}{1\text{ k}\Omega} = 100$

Q- In common emmitor transistor $V_{gain} = 50$
$R_{in} = 1\text{ k}\Omega$
$R_o = 2\text{ k}\Omega$
find power gain

$A_p = A_V^2 \times \frac{R_{in}}{R_o}$

$= (50)^2 \times \frac{1\text{ k}\Omega}{2\text{ k}\Omega} = 1250$

**Common base**

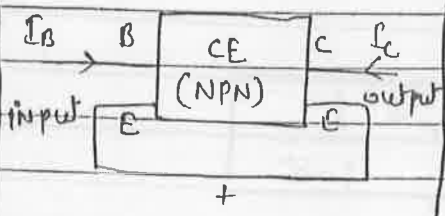



current gain ($\alpha$)

$$\alpha = \frac{I_C}{I_E}$$

$\alpha < 1$

**Common emitter**

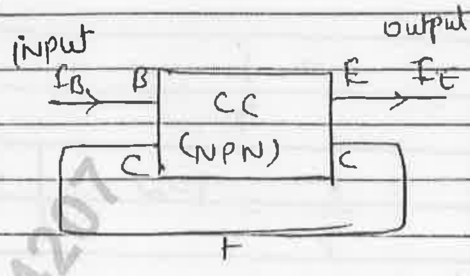



current gain ($\beta$)

$$\beta = \frac{I_C}{I_B}$$

$\beta > 1$

**Common collector**




current gain ($\gamma$)

$$\gamma = \frac{I_E}{I_B}$$

$\gamma > 1$

$\gamma > \beta > \alpha$

Relation b/w $\alpha, \beta, \gamma$

(1) $\frac{I_E}{I_C} = \frac{I_B}{I_C} + \frac{I_C}{I_C}$

$\frac{1}{\alpha} = \frac{1}{\beta} + 1$

$\frac{1}{\alpha} = \frac{1+\beta}{\beta}$

$$\alpha = \frac{\beta}{1+\beta}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

(2) $\frac{I_E}{I_B} = \frac{I_B}{I_B} + \frac{I_C}{I_B}$

$$\gamma = 1 + \beta$$

C.B. $A_V = \alpha \frac{R_o}{R_{in}}$

CE $A_V = \beta \frac{R_o}{R_{in}}$

(3) $\frac{I_E}{I_E} = \frac{I_B}{I_E} + \frac{I_C}{I_E}$ C.C. $A_V = \gamma \frac{R_o}{R_{in}}$

$1 = \frac{1}{\gamma} + \alpha$

$\frac{1}{\gamma} = 1-\alpha$ $\boxed{\gamma = \frac{1}{1-\alpha}}$

(4) $\beta = \frac{I_C}{I_B} = \frac{I_C}{I_E} \times \frac{I_E}{I_B}$

$\boxed{\beta = \alpha\gamma}$

Q- in a Transistor $\alpha = 0.96$ find $\gamma$.

$\alpha = \frac{I_C}{I_E} = 0.96 = \frac{96}{100}$

$\gamma = \frac{I_E}{I_B} = \frac{100}{4} = 25$

Q- $\beta = 19$ find $\alpha$?

$\beta = \frac{I_C}{I_B} = \frac{19}{1}$

$\alpha = \frac{I_C}{I_E} = \frac{19}{20} = 0.95$

Q- In a transistor $10^{10}$ e emmits from emmiter in $10^{-6}$ sec. if 2% emmited ~~et~~ $e^-$ recombine in base find $I_B$, $I_C$ & $\beta$.

$$I_E = \frac{ne}{t} = \frac{10^{10} \times 1.6 \times 10^{-19}}{10^{-6}}$$

$$= 1.6 \times 10^{-3} \text{ A}$$

$$= 1.6 \text{mA}$$

$$I_B = 2\% \, I_E = \frac{2}{100} \times 1.6 \text{ mA} = 0.032 \text{ mA} = 32 \, \mu A$$

$$I_C = I_E - I_B = 1.6 - 0.032 = 1.568 \text{ mA}$$

or $I_C = 98\% \, I_E = \frac{98}{100} \times 1.6 \text{ mA} = 1.568 \text{ mA}$

$$\beta = \frac{I_C}{I_B} = \frac{98\% \, I_E}{2\% \, I_E} = 49$$

Que → In a transistor $I_C = 20$ mA if 10% emmitted charge carriers recombine in base find $I_B$.

$$I_C = 90\% \, I_E$$

$$20 \text{mA} = \frac{90}{100} I_E \Rightarrow I_E = \frac{200}{9} \text{ mA}$$

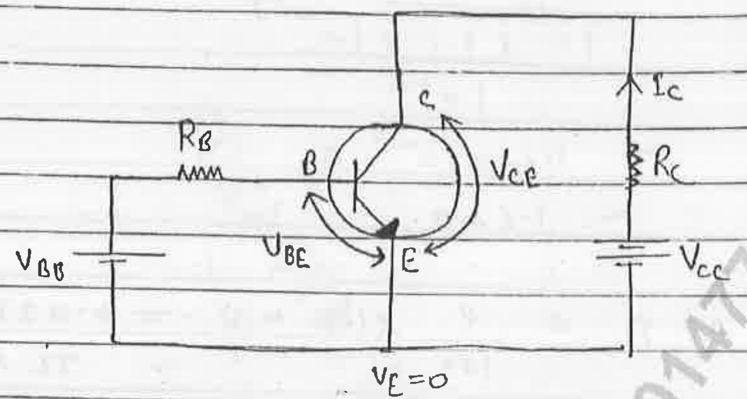
$$I_B = 10\% \, I_E = \frac{10}{100} \times \frac{200}{9} = \frac{20}{9} = 2.25 \text{ mA}$$

2nd method — $\beta = \frac{I_C}{I_B} = \frac{90\% \, I_E}{10\% \, I_E} = 9$

$$I_B = \frac{I_C}{\beta} = \frac{20}{9} \text{ mA}$$

## Application of Transistor —

### ① Transistor as switch →






$$V_{in} = V_{BB} = I_B R_B + V_{BE} \quad \text{--- ①}$$

$$V_{CC} = I_C R_C + V_{CE}$$
$$V_0 = V_{CE} = V_{CC} - I_C R_C \quad \text{--- ②}$$

⇒ when $V_{in} \leq 0.6V$ for Si transistor then — for Si ($V_0 = 0.7$)

$$I_B = 0 , \quad I_C = \beta I_B = 0$$

so $I_B$ & $I_C$ both is 0

transistor is in cutoff mode & work as a open ckt (or) ↳ or off switch.

$V_0 = V_{CE} = V_{CC}$ ↳ output voltage

⇒ when $V_{in} \geq 0.6V$ & $V_{in}$ ↑ses then

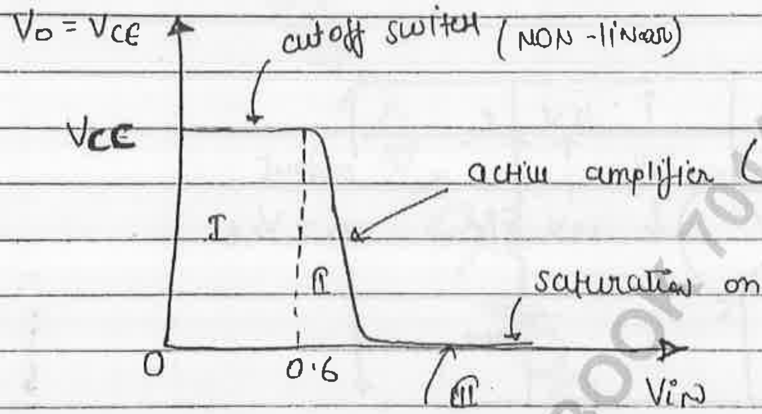
$$I_B \uparrow , \quad I_C = \beta I_B \uparrow\uparrow$$
$$V_0 = V_{CE} = V_{CC} - I_C R_C \downarrow\downarrow$$

When $V_{CE} < V_{BE}$ then $J_{BC} \rightarrow$ F.B. & transistor becomes in saturation mode & work as a close ckt in saturation, $V_{in} \uparrow$

but $I_C$ = const. (max)

$V_O = V_{CE} = V_{CC} - I_C R_C$ constant (min.)

Transistor transfer characteristic curve ⟹ Here transistor work as a close ckt (or) ON switch.




region II → linear region ⟹ amplifier

region I & III → Non-linear ⟹ switch

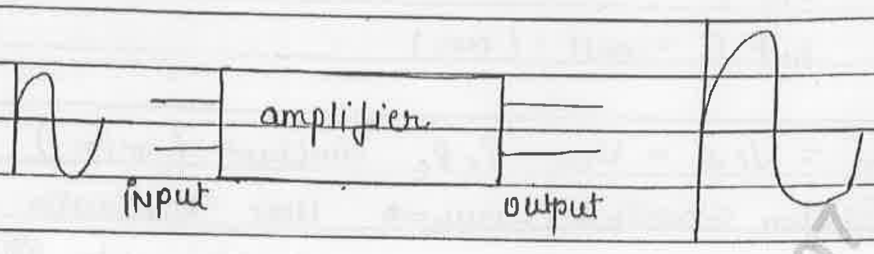
In non linear region CE transistor work as a NOT logic gate. ↳ are used to make NOT logic gate

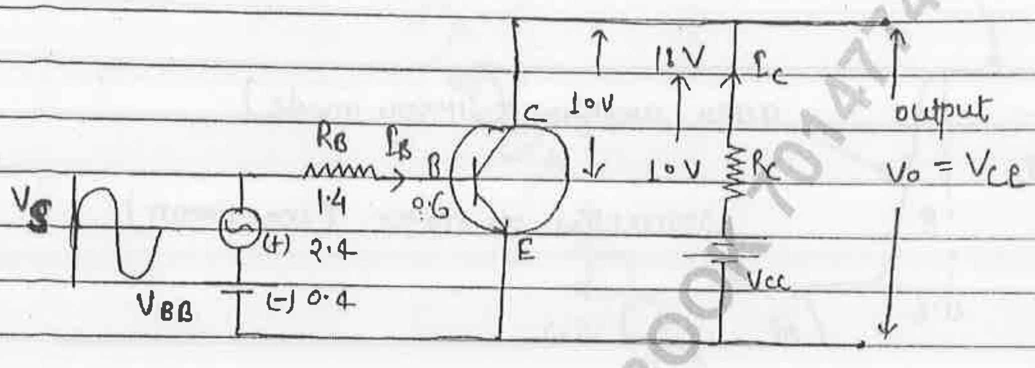
↳ $\boxed{I_C = \beta I_B}$ Valid only in active mode.

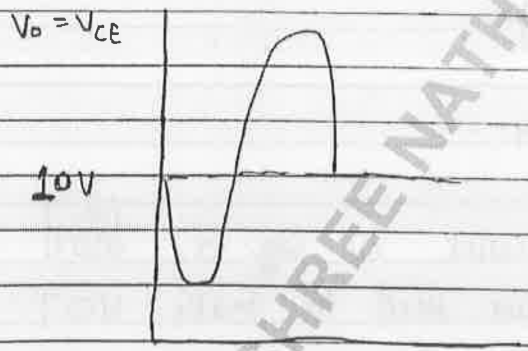
In saturation mode $I_C < \beta I_B$

CHIA TU UKL

## [II] TRANSISTOR AS AN Amplifier






When signal not connected

$$V_{in} = V_{BB} = I_B R_B + V_{BE}$$

When signal $V_s$ connected.

$$V_{in} = \Delta I_B R_B + \Delta V_{BE}$$

imp $\boxed{V_s = \Delta I_B R_B}$ —(1) $(V_{BE} = const)$

$$\Delta V_0 = \Delta V_{CE} = \Delta V_{CC} - \Delta I_C R_C$$

Imp $\boxed{\Delta V_0 = -\Delta I_C R_C}$ —— (2) $\left(\begin{array}{l} V_{CC} = \text{const} \\ \Delta V_{CC} = 0 \end{array}\right)$

Amplification factor $(A_V)$ =

Imp $$\boxed{\frac{\Delta V_0}{\Delta V_{in}} = \frac{-\Delta I_C R_C}{\Delta I_B R_B} = \frac{-\beta R_C}{R_B}}$$

−ve show 180° phase diff b/w input & output signal.

03/01/17

Imp point →

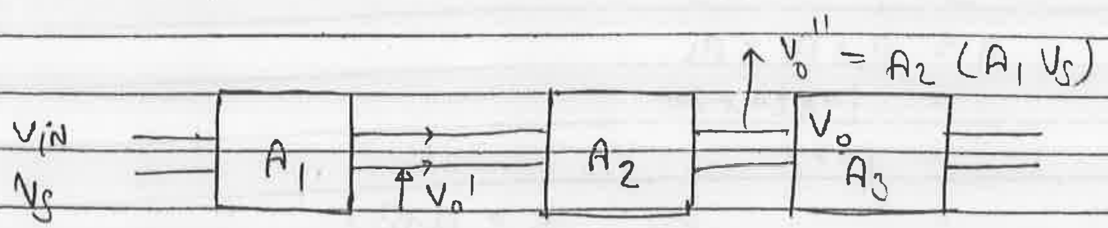
(1) In CE transistor amplifier phase diff $\Delta\phi = 180°$

Amplification factor (A) $= \frac{V_0}{V_s} = -\beta \frac{R_C}{R_B}$

Here −ve sign show 180° phase diff b/w input & output

(2) in CB & CC, phase diff = 0

(3) When CE amplifier are connected in cascade (or) series




$$V_0 = (A_1 \times A_2) V_{in}$$

$$A_1 = \frac{V_0'}{V_{in}} \qquad V_0' = A_1 V_{in}$$

$$\boxed{V_0 = (A_1 \times A_2 \times A_3) V_1}$$

I. When amplifier are in odd no then,

phase diff = $\pi$ rad (or) 180°

even no = 0

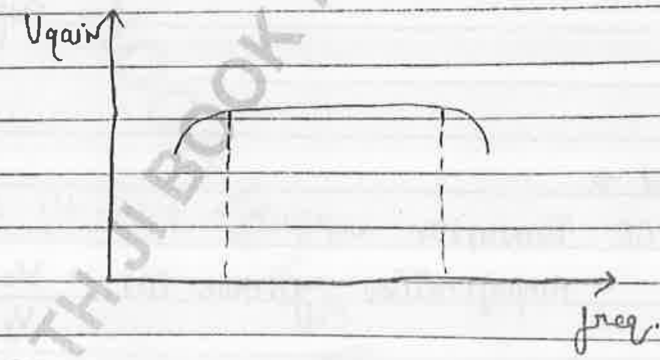
AIIMS

(4) Amplification factor or voltage gain in dB

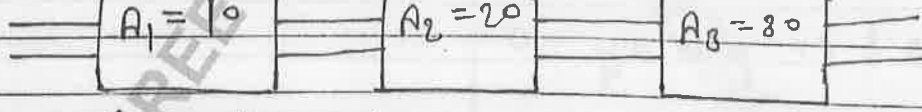
$= 20 \log_{10}(A_V)$ ← amplification factor

NCERT

(5) Graph b/w Vgain & freq of input signal.




NCERT
Qus 1 -
Aipmt 2015




$V_{in} = 0.02 \sin\left(100\pi t - \frac{\pi}{6}\right)$ $V_0 = ?$

$A = A_1 \times A_2 \times A_3$
$= 10 \times 20 \times 30$
$= 1000$

$A = \frac{V_0}{V_{in}}$

~~$V_0 = A V_{in}$~~
~~$= 6000 \times 0.02 \sin\left(100\pi t + \frac{5\pi}{6}\right)$~~

$V_0 = A V_{in}$

$= 6000 \times 0.02 \sin(100\pi t - \pi/6 + \pi)$

$= 120 \sin(100\pi t + 5\pi/6)$

AIIMS AIPMT } in CE Transistor when signal is connected then voltage across the collector resistance 2 KΩ is changed by 2 volt. if β = 100 & base resistance 1 KΩ find signal voltage.

$A = \frac{V_0}{V_s} = \beta \frac{R_C}{R_B}$

$\frac{2}{V_S} = 100 \times \frac{2\,K\Omega}{1\,K\Omega}$

$V_S = \frac{1}{100} = 0.01\,V = 10\,mV$

2nd METHOD →

$\Delta I_C = \frac{\Delta V_C}{R_C} = \frac{2}{2\times 10^3} = 1\,mA$

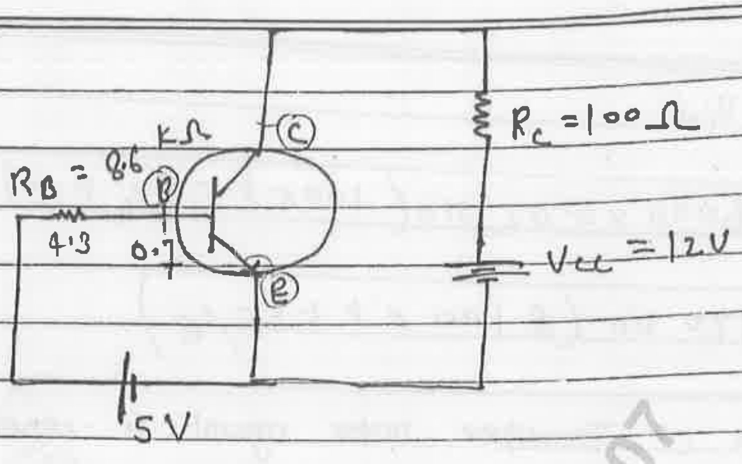
$\Delta I_B = \frac{\Delta I_C}{\beta} = \frac{1}{100}\,mA$

$V_S = \Delta I_B\, R_B$

$= \left(\frac{1}{100}\times 10^{-3}\right) \times 10^3$

$= 0.01\,V = 10\,mV$

I Que → AIIMS 2007




given · $V_{BE} = 0.7V$

$\beta = 100$

find $I_B$, $I_C$ & $V_{CE}$

$$V_{BB} = I_B R_B + V_{BE}$$

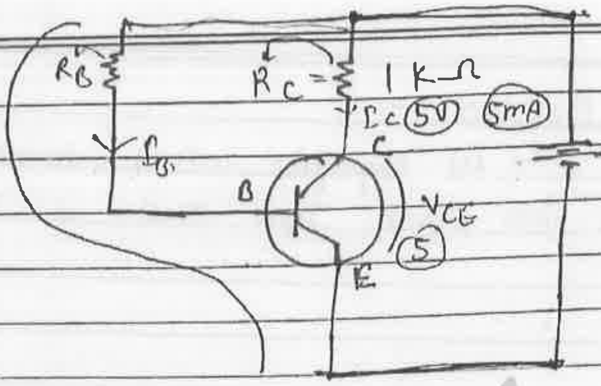
$$V_{CC} = I_C R_C + V_{CE}$$

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5 - 0.7}{8.6 \times 10^{3}} = \frac{1}{2}\ mA$$

$$I_C = \beta I_B = 100 \times \frac{1}{2}\ mA = 50\ mA$$

$$V_{CE} = V_{CC} - I_C R_C$$
$$= 12 - (50 \times 10^{-3}) \times 100$$
$$= 12 - 5$$
$$= 7V$$

Que → $V_{CE} = 5V$
$V_{BE} = 0$
$\beta = 50$
Find $R_B$




$$V_{CC} = I_C R_C + V_{CE}$$

$$V_{CC} = I_B R_B + V_{BE}$$

$$I_C = \frac{V_{CC} - V_{CE}}{R_C} = \frac{10-5}{1K\Omega} = 5mA$$

$$I_B = \frac{I_C}{\beta} = \frac{5}{50} mA = \frac{1}{10} mA$$

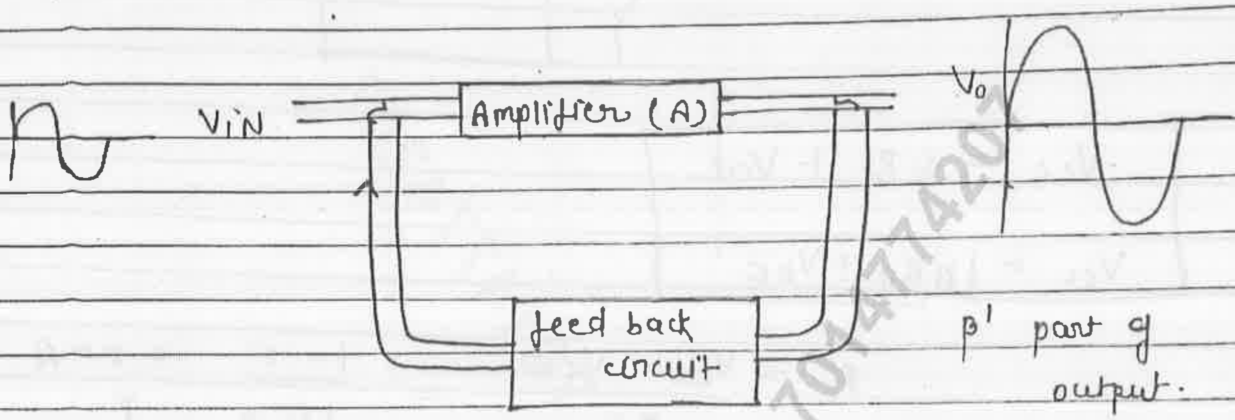
$$V_{CC} = I_B R_B + V_{BE}$$

$$10 = \left(\frac{1}{10} \times 10^{-3}\right) R_B + 0$$

$$R_B = 100 K\Omega$$

1. Concept of feed back –

↳ in amplifier when some part of output is again feed into input then this is k/w as concept of feedback.




**Positive feedback** → in +ve feedback input & output are superimpose in same phase.

voltage gain after +ve feed back

$$A_f = \frac{A}{1 - A\beta'}$$

A = voltage gain before feedback

$A_f$ = voltage gain after feedback

β' = part of output feed into input.

$$V_o = A_f \times V_{in}$$

use :- in oscillator

[2] negative feedback → input & output are superimpose in opp. phase.

voltage gain after -ve feedback.

$$A_f = \frac{A}{1 + A\beta}$$

$$V_o = A_f \times V_{in}$$

use:- to reduce noise.

~~Imp. point:~~

Que:- After 9% negative feedback voltage gain is 10 find voltage gain before feedback & after feedback

NEET 2008

$$A_f = \frac{A}{1 + A\beta}$$

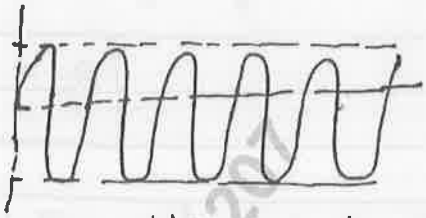
$$10 = \frac{A}{1 + A(9/100)}$$

$$10 + 0.9A = A$$

$$A = \frac{10}{0.1} = 100$$

TRANSISTOR as an oscillator :- Oscillator is a device which generate oscillation of const. amplitude (sustain oscillation) without any AC input signal.

Oscillator are used to generate ~~carrier wave in modulation~~ · carrier wave in communication (modulation)



(i) in oscillator oscillation generate by LC ckt : but due to energy loss its Nature is → damped

$$\text{freq. of oscillation} = \frac{1}{2\pi\sqrt{LC}}$$

(ii) in oscillator Transistor work as an amplifier & with the help of ⊕ve feed back it convert damped oscillation into sustain oscillation

3 (iii) Condition for stable oscillation :-

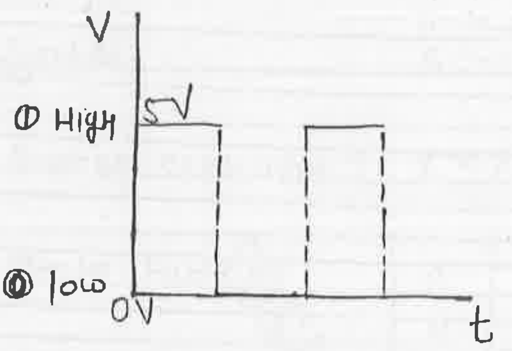
$$A\beta' = 1$$ $$\beta' = \frac{1}{A}$$

Demorgan Theorem :-

$\overline{A+B+C} = \bar{A}\cdot\bar{B}\cdot\bar{C}$

$\overline{A\cdot B\cdot C} = \bar{A}+\bar{B}+\bar{C}$

## DIGITAL ELECTRONICS :- / (LOGIC GATES) :-




(I) logic gate is an electronic ckt construct by diode in transistor

(II) logic gate use to perform mathematical operation of Digital signals. (boolean algebra).

(III) logic gate based on logically relation b/w input & output

### LAW OF Boolean Algebra :-

| Addition | multiplication | inversion |
|---|---|---|
| $A+0 = A$ | $A\cdot 0 = 0$ | $A+\bar{A} = 1$ |
| $A+1 = 1$ | $A\cdot 1 = A$ | $A\cdot\bar{A} = 0$ |
| $A+A = A$ | $A\cdot A = A$ | $\bar{\bar{A}} = A$ |

### Useful identities

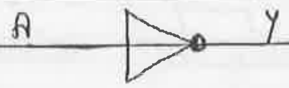
- $A + A\cdot B$
  $A(1+B)$
  $A\cdot 1$
  $= A$

- $A\cdot(A+B)$
  $A\cdot A + A\cdot B$
  $A + A\cdot B$
  $= A$

- $A+$

## [C] NOT gate ( invert gate ) :-

(I) Symbol :-

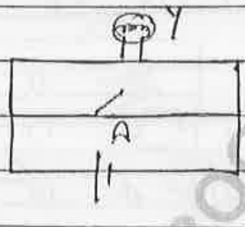



(II) Boolean expression :- $Y = \bar{A}$

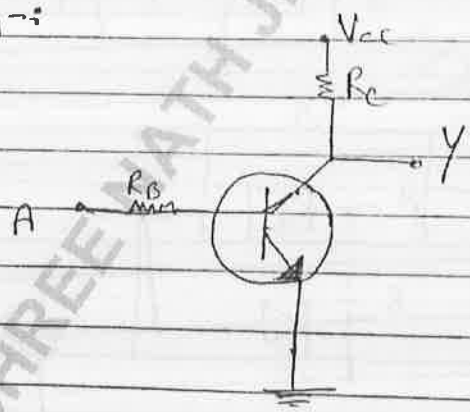
(III) Truth Table :-

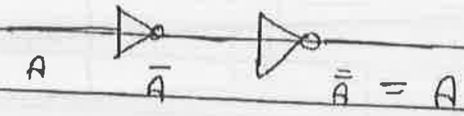
| A | Y |
|---|---|
| 0 | 1 |
| 1 | 0 |

(IV) Eq. electric ckt :-



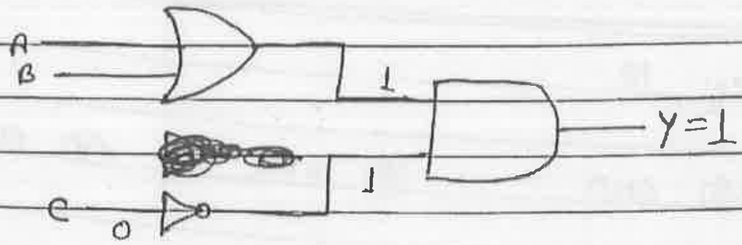

(V) Real ckt diagram :-




$\bar{\bar{A}} = A$

Que -



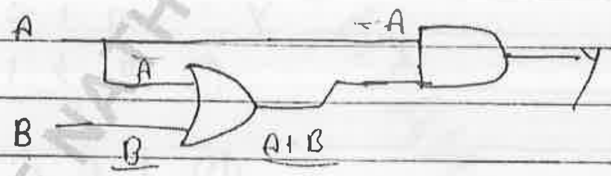

Y = 1 when

| | A | B | C |
|---|---|---|---|
| (I) | 1 | 0 | 1 × |
| (II) | 1 | 1 | 1 × |
| ✓ (III) | 0 | 1 | 0 |
| (IV) | 0 | 0 | 0 × |



Que - Y will be equal to -

(1) A (2) B (3) A+B (4) A·B




| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

$Y = A\cdot(A+B)$

$= A\cdot A + A\cdot B$

$= A + A\cdot B$

$= A(1+B)$

$= A$

$Y = A\cdot(A+B)$

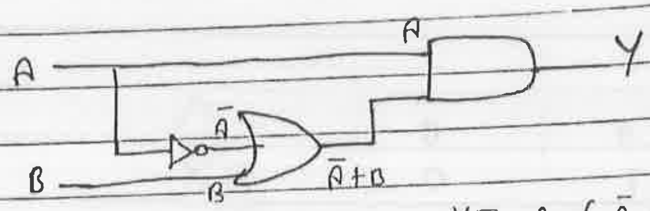
$= 0$

$= 1\cdot(1+0)$

$Y = A$

Que :- Given ckt eq to

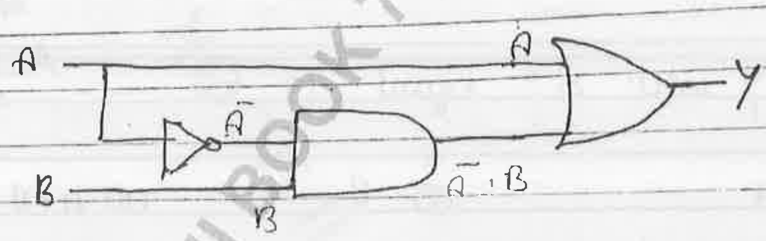
(i) OR  (ii) AND  (iii) NOR  (iv) NAND




$$Y = A\cdot(\bar{A}+B)$$
$$= A\cdot\bar{A} + A\cdot B$$
$$= 0 + A\cdot B$$
$$= A\cdot B$$

Que :-

ANS - OR gate




$$Y = A + \bar{A}\cdot B$$

(i) $0 + 1\cdot 0$

(ii) $1 +$ ·

(v)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

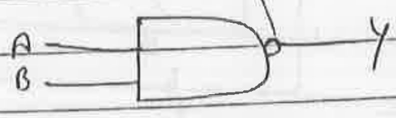
2nd method -

$$Y = A + \bar{A}\cdot B$$
$$= A\cdot(1+B) + \bar{A}\cdot B$$
$$= A\cdot 1 + A\cdot B + \bar{A}\cdot B$$
$$= A + B(A+\bar{A})$$
$$= A+B$$

## [B] Universal Logic Gate -:

### ① NAND gate -: (AND + NOT)

(i) symbol -

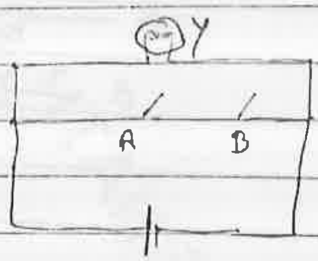



(ii) Boolean exp -: $Y = \overline{A \cdot B}$

(iii) Truth Table -:

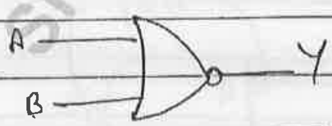
| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

(iv) equivalent electric ckt




### ② NOR gate (OR + NOT)

(i) symbol -

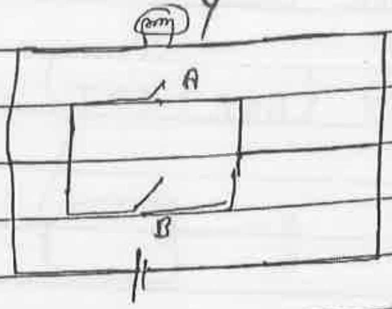



(ii) Boolean exp:- $Y = \overline{A + B}$

(iii) Truth Table -

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

(IV) Equiv. electric ckt :-

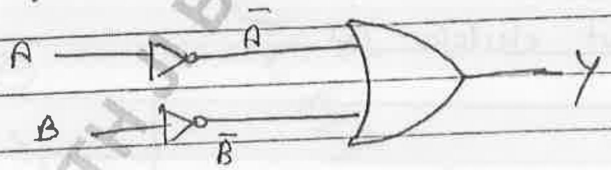



De. Morgan Theorem :-

$$\overline{A+B} = \bar{A}\cdot\bar{B}$$

$$\overline{A\cdot B} = \bar{A}+\bar{B}$$

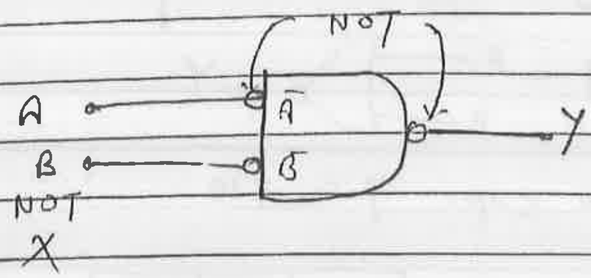
Qus → Given ckt eq. to –




$$Y = \bar{A}+\bar{B}$$
$$= \overline{(A\cdot B)}$$

NAND gate

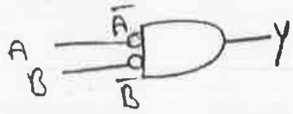
Qus :-




$$Y = \overline{\bar{A}\cdot\bar{B}} = \bar{\bar{A}} + \bar{\bar{B}}$$
$$= A+B$$

OR

Given combinⁿ eq. to

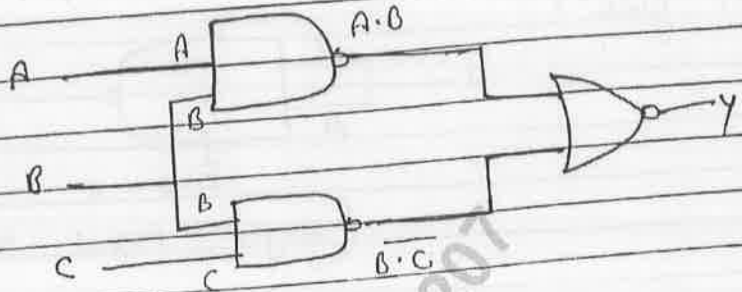
① 


$Y = \overline{\bar{A} \cdot \bar{B}}$

$= \overline{A + B}$

NOR

Given ckt eq to –

③ 


$Y = \overline{\overline{A \cdot B} + \overline{B \cdot C}}$

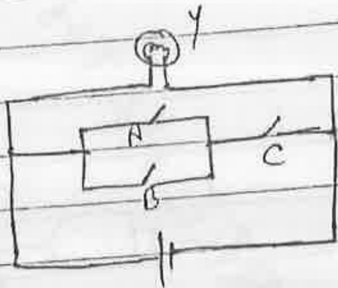
$= \overline{\overline{A \cdot B}} \cdot \overline{\overline{B \cdot C}}$

$(B \cdot B = B)$ $= A \cdot B \cdot B \cdot C$

$A \cdot B \cdot C$

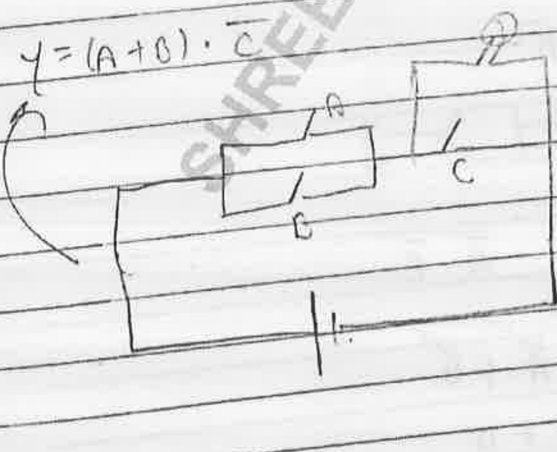
AND gate

Q – write boolean expres



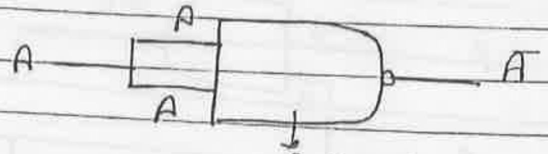

$Y = \overline{(A + B) \cdot C}$

$Y = (A + B) \cdot \bar{C}$



= Conversion of NAND & other gates —:

① NOT gate —:



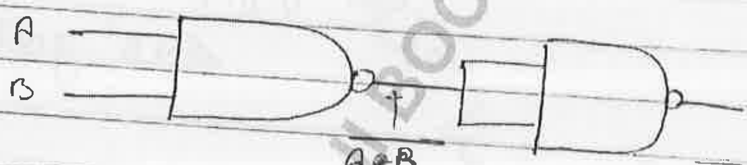

$A \cdot A = A$

(single input NAND)

② AND gate —:

NAND = AND + NOT

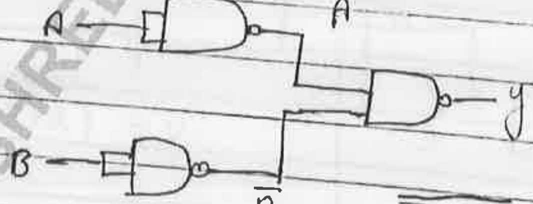
(AND + NOT + NOT)




$\overline{\overline{A \cdot B}}$

$= A \cdot B$

③ OR gate —:

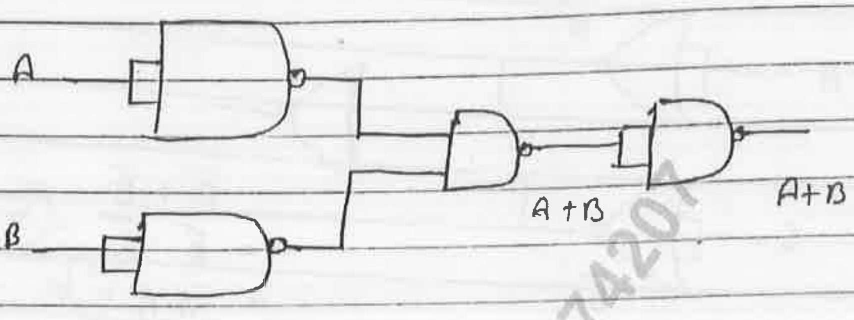



$\overline{\bar{A} \cdot \bar{B}}$

$\bar{\bar{A}} + \bar{\bar{B}}$

$A + B$

(4) NOR gate = OR + NOT

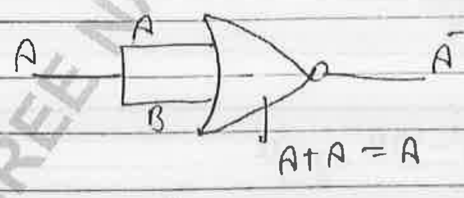



Required min. NAND gate

NOT → 1
AND → 2
OR → 3
NOR → 4

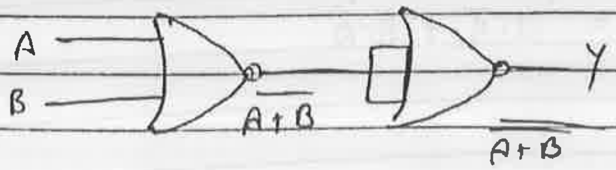
CONVERSION OF NOR gate into other gate :-

(1) NOT gate :-



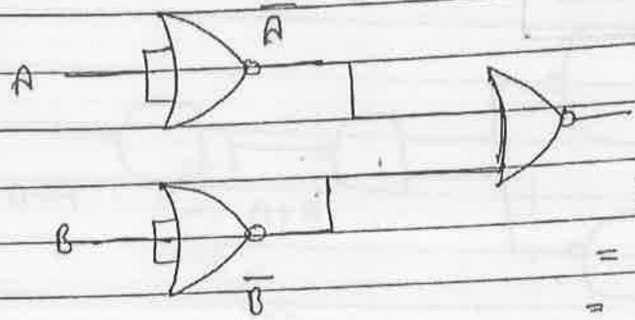

(single input NOR)

(2) OR gate :-



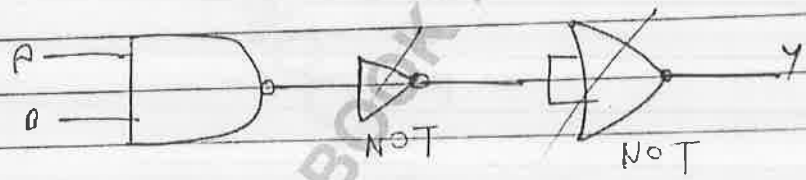

$= A + B$

(3) AND :-




$\overline{\bar{A} + \bar{B}}$
$= \bar{\bar{A}} \cdot \bar{\bar{B}}$
$= A \cdot B$

AIIMS
Q1. :- equiv. to

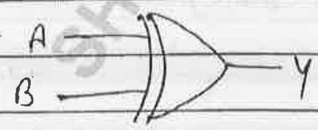



NAND.

special gate :-

[1] XOR gate (or) Ex - OR gate

(i) Symbol –




(ii) Boolean expression – $Y = A \oplus B$
$= A\cdot\bar{B} + B\cdot\bar{A}$

$\overline{\overline{A\cdot\overline{B}} + \overline{B\cdot\overline{A}}}$ $\quad (\overline{\overline{A}} + \overline{\overline{B}}) \cdot (\overline{\overline{B}} + \overline{\overline{A}})$

$\overline{A\cdot\overline{B}} + \overline{B\cdot\overline{A}}$ $\quad (\overline{A} + B) \cdot (\overline{B} + A)$

$\overline{A}\cdot\overline{B} + \overline{A}\cdot A + B\cdot\overline{B} + B\cdot A$

$\overline{A}\cdot\overline{B} + A\cdot B$

(II) Truth Table :-

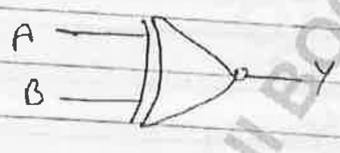
| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

Output will be High when both input are different.

(2) XNOR gate or Ex-NOR gate

XNOR = XOR + NOT

(i) Symbol



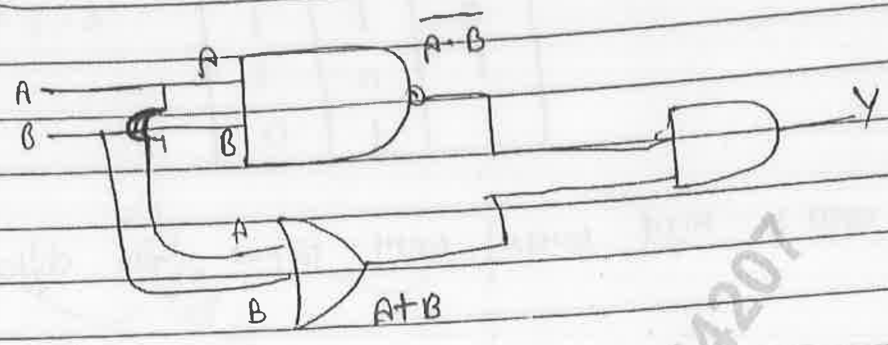

(ii) Boolean expression :- $Y = A \odot B$

$= \overline{A\cdot\overline{B} + B\cdot\overline{A}}$ $\quad A\cdot B + \overline{A}\cdot\overline{B}$

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Output HIGH when both input are same.

Q- Write Truth table →




$Y = (A+B) + (\overline{A \cdot B})$

$= (A+B) + (\bar{A} + \bar{B})$

$= \bar{A} \cdot \bar{A} + A \cdot \bar{B} + B \cdot \bar{A} + \bar{B} \cdot \bar{B}$

$= A \cdot \bar{B} + B \cdot \bar{A}$

= XOR gate

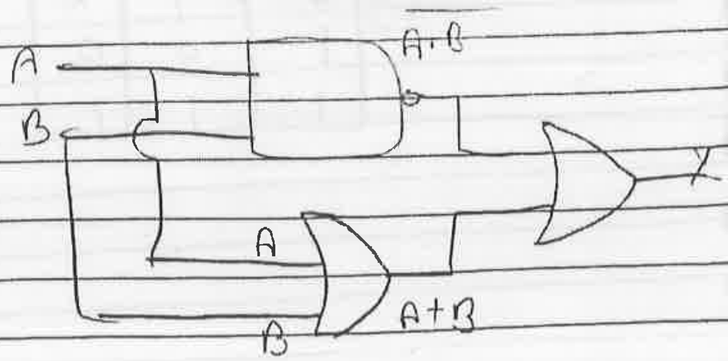
| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

Q → $Y = A + B + \overline{A \cdot B}$

$= A + B + \bar{A} + \bar{B}$

$= A + \bar{A} + B + \bar{B}$

$= 1 + 1 = 1$




| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

Ques:- Two Radioactive element x & y have decay constant $5\lambda$ & $2\lambda$ respectively. If Initially both have same no. of nuclei then calculate the time after which the ratio of No. of nuclei becomes $\left(\frac{1}{e}\right)^2$?

Sol.

$$N = N_0 e^{-\lambda t}$$

$$N_x = N_0 e^{-5\lambda t} \quad -(1)$$

$$N_y = N_0 e^{-2\lambda t} \quad -(2)$$

$$\frac{N_x}{N_y} = \frac{N_0 e^{-5\lambda t}}{N_0 e^{-2\lambda t}}$$

$$\left(\frac{1}{e}\right)^2 = e^{-3\lambda t}$$

$$e^{-2} = e^{-3\lambda t}$$

$$-2 = -3\lambda t$$

$$t = \frac{2}{3\lambda} \quad \text{Ans.}$$

Ques:- The mean life of a radioactive element is 10yrs. then calculate the half life of the element.

Sol.

$$t_{mean} = \frac{1}{\lambda} \Rightarrow 10 = \frac{1}{\lambda}$$

$$t_{1/2} = \frac{0.693}{\lambda} = 0.693 \times 10 = ~~0.07~~ \text{ yrs.}$$

6.93 years

Ques:- The half life of two radioactive elements are 20 yrs. & 5 yrs. respectively. If at any Instant their activities are equal then calculate the ratio of No. of undecayed Nuclei at that instant?

Sol:- $A_0 = A_0 e^{-\lambda t}$

$1 = e^{-\lambda t}$

$1 = e^{-\lambda \times 1}$

$e^{-\lambda} = 1$

$\frac{A_0}{\sqrt{3}} = A_0 e^{-\lambda \times 4}$

$A = A_0 e^{-\lambda t}$

पहली → $\frac{A_0}{\sqrt{3}} = A_0 e^{-\lambda(1)}$

$e^{-\lambda} = \frac{1}{\sqrt{3}}$ — (1)

फिर से → $A = A_0 e^{-\lambda t}$

$A = A_0 e^{-\lambda(4)}$

$A = A_0 [e^{-\lambda} \cdot e^{-\lambda} \cdot e^{-\lambda} \cdot e^{-\lambda}]$

$A = A_0 \left[\frac{1}{\sqrt{3}} \cdot \frac{1}{\sqrt{3}} \cdot \frac{1}{\sqrt{3}} \cdot \frac{1}{\sqrt{3}}\right] = A_0 \left(\frac{1}{9}\right) = \frac{A_0}{9}$ **Ans:**

**Que:** Two Radioactive nuclei x and y have decay constant $10\lambda$ & $\lambda$ respectively. If Initially both have same no. of Nuclei, then calculate the time after which the ratio of their nuclei becomes $\frac{1}{e}$?

Sol:

$N_x = N_0 e^{-10\lambda t}$

$N_y = N_0 e^{-\lambda t}$

$\frac{N_x}{N_y} = e^{-9\lambda t}$

$\frac{1}{e} = e^{-9\lambda t}$

$e^{-1} = e^{-9\lambda t}$

$-1 = -9\lambda t$

$t = \frac{1}{9\lambda}$ Ans.

MIRAJ

## PROBLEMS.

Ques:- The half life of the radioactive element $^{238}_{92}U$ is $4.5 \times 10^9$ years. calculate the activity of 1 gm. sample of $^{238}_{92}U$ ?

Sol:-

$$t_{1/2} = \frac{0.693}{\lambda} \qquad 4.5 \times 10^9 \times 365 \times 24 \times 60 \times 60 \text{ seconds}$$

$4.5 \times 10^9$ years $\lambda = 0.693$

Second में change करें

$$\lambda = \frac{0.693}{4.5 \times 10^9 \times 365 \times 24 \times 60 \times 60}$$

$A = \lambda N$

For $^{238}_{92}U \Rightarrow$ 238 gm में आते कितने atoms $= N_A$

$$1gm \longrightarrow \frac{N_A}{238} = \frac{6.023 \times 10^{23}}{238}$$

N = यह No. of atom है No. of Nuclei है।

$$A = \frac{0.693}{4.5 \times 10^9 \times 365 \times 24 \times 60 \times 60} \times \frac{6.023 \times 10^{23}}{238}$$

$$= \frac{4.17 \times 10^{14}}{92534400} \simeq$$

Ques:- The activity of a sample reduces from $A_0$ to $\frac{A_0}{\sqrt{3}}$ in one hour. Calculate the activity of the sample after 3 hrs. more will be

1) $\frac{A_0}{3}$ 2) $\frac{A_0}{9}$ 3) $\frac{A_0}{3\sqrt{3}}$ 4) $\frac{A_0}{81}$

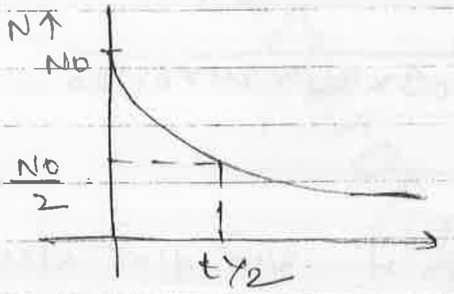
## GOLDEN KEY POINTS :-

1) Spontaneous, Random Process.

2) Rutherford's Law → $N = N_0 e^{-\lambda t}$

$N_0 \rightarrow$ Initial No of Nuclei

$N \rightarrow$ No. of undecayed Nuclei (active)




3) Half Life ⇒ $t_{1/2} = \frac{0.693}{\lambda}$

4) Mean Life ⇒ $t_{mean} = \frac{1}{\lambda}$

5) $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$

6) Unit of A → d.p.s (Becqurrel)

$1 Bq = 1 d.p.s$

7) $A = \lambda N$

$A = A_0 e^{-\lambda t}$

Activity :- The activity is defined as the rate of disintegration of a radioactive Nuclei.

→ It is represented by 'A'.

→ Its unit is disintegration $sec^{-1}$ (dps) or (Becquerel) 1 Bq = 1 dps

and curie (Ci)

1 curie = $3.7 \times 10^{10}$ dps

$$A = \left|-\frac{dN}{dt}\right|$$

$$\boxed{A = \lambda N}$$

A = Activity

$\lambda$ = decay constant

N = No. of undecayed Nuclei

unit → d.p.s

$t = 0 \longrightarrow N_0 \longrightarrow A_0$

after time 't' $\longrightarrow N \longrightarrow A$

$A = \lambda N$

$A_0 = \lambda N_0$ — (a)

$A = \lambda N$ — (b)

eq^n (b)/(a)

$$\frac{A}{A_0} = \frac{\lambda N}{\lambda N_0} = \frac{N_0 e^{-\lambda t}}{N_0}$$

$$\boxed{A = A_0 e^{-\lambda t}}$$

NCERT page - 446

Que:- The half life of the Redon, a radioactive element is 1600 yrs then calculate the time after which $\frac{15}{16}$ fraction of the initial bec becomes decayed ?

Sol.

Initial = $N_0$

~~after steps~~ —

A/c to Question → $N = \frac{N_0}{16}$ (i.e $N_0 - \frac{15N_0}{16}$)

$N_0 — \frac{N_0}{2} — \frac{N_0}{4} — \frac{N_0}{8} — \frac{N_0}{16}$

$4 \times t_{1/2} = \frac{N_0}{16} \Rightarrow 4 \times 1600 = 6400\,yrs$ Ans

Or

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}} \Rightarrow \frac{N_0}{16 N_0} = \left(\frac{1}{2}\right)^{t/1600} \Rightarrow \frac{t}{1600} = 4$

$t = 6400$ yrs

## MEAN LIFE (Avg. LIFE)

The time interval after which the no. of undecayed Nuclei becomes $\left(\frac{1}{e}\right)$ of its initial value.

$N = N_0 e^{-\lambda t}$ — (1) at $t \to t_{mean}$, $N \to \frac{1}{e} N_0$

$\Rightarrow \frac{1}{e} N_0 = N_0 e^{-\lambda t_{mean}} \Rightarrow \frac{1}{e} = e^{-\lambda t_{mean}} \Rightarrow e^{-1} = e^{-\lambda t}$

(base same then Power same)

$-1 = -\lambda t_{mean}$

$$t_{mean} = \frac{1}{\lambda}$$

METHOD #03

**Note** → $t = t_{1/2}$ ① $N = \frac{N_0}{2} = \frac{1}{2} N_0$

$t = 2t_{1/2}$ $N = \frac{N_0}{4} = \left(\frac{1}{2}\right)^2 N_0$

$t = 3t_{1/2}$ $N = \frac{N_0}{8} = \left(\frac{1}{2}\right)^3 N_0$

$t = n\,t_{1/2}$ $N = \left(\frac{1}{2}\right)^n N_0$

$\Rightarrow n = \frac{t}{t_{1/2}} \Rightarrow N = \left(\frac{1}{2}\right)^{t/t_{1/2}} N_0$

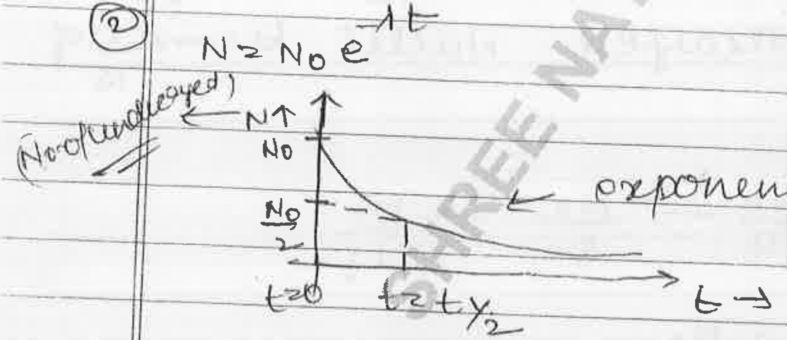
$$\boxed{\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}}$$

Previous Q' →

$\frac{N_0/16}{N_0} = \left(\frac{1}{2}\right)^{t/400}$

$\left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^{t/400} \Rightarrow \frac{t}{400} = 4 \Rightarrow t = 1600$

② $N = N_0 e^{-\lambda t}$

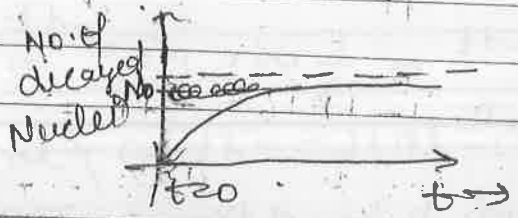





# No. of decayed Nuclei v/s t →

No. of decayed Nuclei $= N_0 - N$

No. of decayed Nuclei $= N_0 - N_0 e^{-\lambda t} = N_0(1 - e^{-\lambda t})$



**Half Life ($t_{1/2}$) :-** The time interval after which no. of undecayed Nuclei becomes 50% of its initial value

$$N = N_0 e^{-\lambda t} \quad -(1)$$

$t \longrightarrow t_{1/2}$

$N \longrightarrow \frac{N_0}{2}$

$$\frac{N_0}{2} = N_0 e^{-\lambda t_{1/2}} \Rightarrow \frac{1}{2} = e^{-\lambda t_{1/2}} \Rightarrow \ln\frac{1}{2} = -\lambda t_{1/2}$$

$$\ln 1 - \ln 2 = -\lambda t_{1/2} \Rightarrow 0 - \ln 2 = -\lambda t_{1/2}$$

$$-\ln 2 = -\lambda t_{1/2} \Rightarrow \frac{\ln 2}{\lambda} = t_{1/2}$$

$$\boxed{t_{1/2} = \frac{0.693}{\lambda}}$$

**Ques:** If the half life of the radioactive element is 400 yrs. calculate the time after which no. of undecayed Nuclei become $\frac{1}{16}$ of its initial value?

**Sol**

$$N_0 \xrightarrow{t_{1/2}} \frac{N_0}{2} \xrightarrow{t_{1/2}} \frac{N_0}{4} \xrightarrow{t_{1/2}} \frac{N_0}{8} \xrightarrow{t_{1/2}} \frac{N_0}{16}$$

$$4 \times t_{1/2} = \frac{N_0}{16}$$

$$4 \times 400 = \frac{N_0}{16}$$

$$\frac{N_0}{16} = \underline{1600 \text{ yrs.}}$$

(or)

Method 2
For Boards

$$\Rightarrow N = N_0 e^{-\lambda t} \Rightarrow \frac{1}{16} N_0 = N_0 e^{-\lambda t} \Rightarrow \frac{1}{16} = e^{-\lambda t}$$

$$\ln\frac{1}{16} = -\lambda t \Rightarrow \ln 1 - \ln 16 = -\lambda t \Rightarrow \ln 16 = \lambda t$$

$\ln 2^4$ = ... $4\ln 2$ ... $t \Rightarrow 4 t_{1/2}$ ... $\Rightarrow 4 \times 400$ ...

18 sep



# RADIOACTIVITY

Random, spontaneous

Rutherford Radioactivity Law:-
A/C to this law, the rate of disintegration of a radioactive nuclei is directly proportional to number of active nuclei present at that time.

$$\boxed{-\frac{dN}{dt} \propto N}$$

$N_0$ = Initial no of Nuclei at $t=0$

N = जो 't' समय बाद बचे हैं (undecayed fraction)

$$-\frac{dN}{dt} = \lambda N$$

λ → Decay const. जिनका decay होना बाकी है

$$\Rightarrow -\frac{dN}{dt} = \lambda dt \Rightarrow \int_{N_0}^{N} \frac{dN}{N} = -\int_{t=0}^{t} \lambda\, dt$$

$$[\ln N]_{N_0}^{N} = -\lambda [t]_0^t$$

$$\ln N - \ln N_0 = -\lambda [t-0]$$

$$\Rightarrow \ln \frac{N}{N_0} = -\lambda t$$

$$\frac{N}{N_0} = e^{-\lambda t}$$

$$\boxed{N = N_0 e^{-\lambda t}}$$

UNIT of λ → λ → decay const

= sec$^{-1}$, day$^{-1}$, year$^{-1}$ | i.e. Time$^{-1}$

$$t_{1/2} = \frac{0.693}{\lambda}$$

## γ- Decay

Like atoms, Nucleus also have energy levels i.e Ground state, excited state

During Gamma decay –

mass no. (A) तथा atomic no. (Z) ⟶ कोई change नहीं होगा।

GOLDEN KEY POINTS:-

α-decay $\quad {}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He + Q$

$\beta^{\ominus}$-decay $\quad {}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \bar{\nu} + Q$

$\beta^{\oplus}$-decay $\quad {}^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e + \nu + Q$

β-decay में कभी भी mass no. (A) change नहीं होता।

γ-decay $\quad {}^{A}_{Z}X \longrightarrow {}^{A}_{Z}X + Q$ ← देखाने this is due to energy level diff.

PROBLEMS:

**Que:** ${}^{238}_{92}U \longrightarrow {}^{206}_{82}Pb$ कितने α, तथा कितने β particle निकलते।

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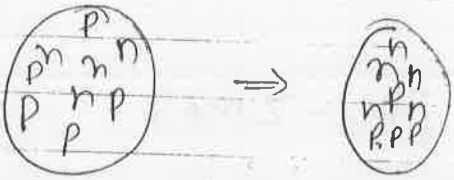
Date:



A = 9      A = 9
Z = 5      Z = 4

$$^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e + \nu + Q$$

(Positron) (Neutrino)

for Q-value → $^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e + \nu + Q$

atomic mass   $M_x$   $M_y$   $M_e$

Mass of Reactant = $M_x - ZMe$
mass of Product = $(M_y - (Z-1)me + me)$

$= (M_y - Zme + 2me)$

$\Delta m$ = Mass of Reactant - mass of product

$\Delta m = (M_x - ZMe) - (M_y - Zme + 2me)$

$= M_x - ZMe - M_y + Zme - 2m_e$

$\Delta m = (M_x - M_y - 2m_e)$

अब . Q-value = $(\Delta m)c^2$

$$\text{Q-Value} = (M_x - M_y - 2Me)c^2$$

$\beta^{+}$ - Revesited → of Point →

(1) $^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e + \nu + Q$

(2) Q-value = $[M_x - M_y - 2Me]c^2$

Mass of Reactant = $[M_x - ZM_e]$

Mass of product = $[M_y - (Z+1)m_e + m_e]$

$= M_y - ZM_e - m_e + m_e$

mass of product = $M_y - ZM_e$

$\Delta m$ = mass of Reactant − mass of product

$\Delta m = [M_x - ZM_e] - [M_y - ZM_e]$

$\Delta m = M_x - ZM_e - M_y + ZM_e$

$$\boxed{\Delta m = M_x - M_y}$$

अतः → $Q = (\Delta m)c^2$

$$\boxed{Q = (M_x - M_y)c^2}$$

Proton = ${}_{1}^{1}p$

Neutron = ${}_{0}^{1}n$

electron = ${}_{-1}^{0}e$

Positron : ${}_{+1}^{0}e$ (धनात्मक mass $e^-$ के बराबर होता)

$\beta^{\ominus}$-decay Revisited →

दो बात !

(1) ${}_{Z}^{A}X \longrightarrow {}_{Z+1}^{A}Y + {}_{-1}^{0}e + \overline{\nu}$ + Q-Value

(2) $\boxed{Q = (M_x - M_y)c^2}$

(B) $\beta^{\oplus}$-decay

Emission of positron from Nucleus

${}_{1}^{1}p \longrightarrow {}_{0}^{1}n + {}_{+1}^{0}e + \nu$

Neutrino

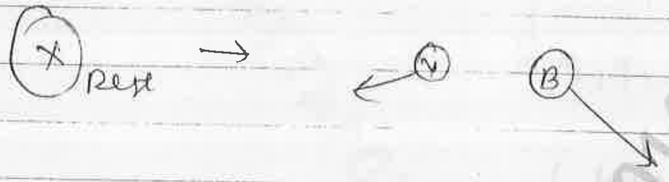
Law of conservation को violate कर रहे थे →

① Law of conservation of Energy →

$K.E_{\gamma} + K.E_{\beta} < Q$

$K.E_{\beta} \rightarrow$ varying

② Law of conservation of momentum →




③ Law of conservation of ang. momentum

$^{1}_{0}n \longrightarrow {}^{1}_{1}P + {}^{0}_{-1}e$ (spin $\pm\frac{1}{2}\left(\frac{h}{2\pi}\right)$)

$+\frac{1}{2}\left(\frac{h}{2\pi}\right) = \pm\frac{1}{2}\left(\frac{h}{2\pi}\right) \pm \frac{1}{2}\left(\frac{h}{2\pi}\right)$

$\frac{h}{2\pi}$ or $0$

To disprove the violation

Neutrino Hypothesis

→ anti neutrino ($\bar{\nu}$)

→ neutrino ($\nu$)

- → charge = 0
- → Energy particle like photon
- → बहुत कम mass
- → $\pm\frac{1}{2}$ spin

यहाँ ⇒ $^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \bar{\nu} + Q$

↓ Anti Neutrino

For Q-value →

$^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \bar{\nu} + Q\text{-Value}$

atomic mass → $M_X$  $M_Y$  $M_e$

## α- decay Revisited :-

तीन Points ⇒ ~~+1~~ = 4

(1) $^{A}_{Z}X \longrightarrow ^{A-4}_{Z-2}Y + ^{4}_{2}He + Q$

(2) $K.E_{\alpha} = \left[\frac{A-4}{A}\right] Q$

(3) α – particle
- → He nuclei
- → (2p) (2n)
- → (+ve charged)

(4) Q value = $(M_x - M_y - M_{He})c^2$

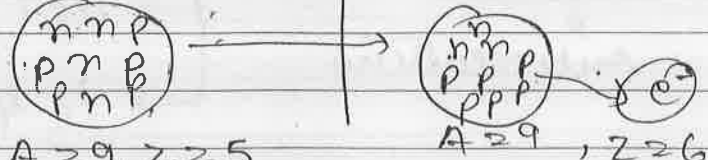
β- Decay → 
- → $\beta^-$ decay
- → $\beta^+$ decay

(A) $\beta^-$ decay
⇓
electron

- emission of $e^-$ from Nucleus.

$^{1}_{0}n \longrightarrow ^{1}_{1}p + ^{0}_{-1}e$ → emit ($\beta^-$- particle)

पहले | बाद




β – decay

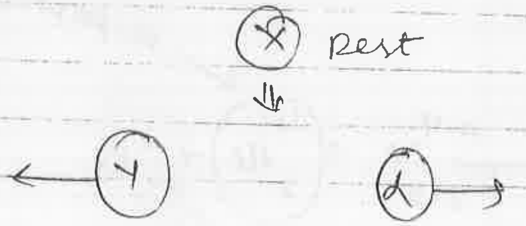
A = 9, Z = 5 | A = 9, Z = 6

$^{A}_{Z}X \longrightarrow ^{A}_{Z+1}Y + ^{0}_{-1}e + Q$ ← Incomplete

↑ electron ($\beta^-$ particle)

## ** Kinetic Energy of emitted $\alpha$ - particle →

$$K.E_Y + K.E_\alpha = Q \quad -(1)$$




<u>Conservation of momentum</u> ⇒

$$0 = P_Y + P_\alpha$$

$$\boxed{P_\alpha = P_Y}$$

$$K.E = \frac{P^2}{2m} \Rightarrow \frac{K.E_Y}{K.E_\alpha} = \frac{m_\alpha}{m_Y}$$

$$\boxed{K.E_Y = \frac{m_\alpha}{m_Y} \cdot K.E_\alpha}$$

from (1) $\quad K.K.Y + K.E_\alpha = Q$

$$\Rightarrow \frac{m_\alpha}{m_Y} \cdot K.E_\alpha + K.E_\alpha = Q$$

$$\Rightarrow K.E_\alpha \left[\frac{m_\alpha}{m_Y} + 1\right] = Q$$

$$\Rightarrow K.E_\alpha \left[\frac{m_\alpha + m_Y}{m_Y}\right] = Q$$

$$\Rightarrow K.E_\alpha = \left[\frac{m_Y}{m_\alpha + m_Y}\right] Q \Rightarrow K.E_\alpha = \left[\frac{(A-4)m_p}{4m_p + (A-4)m_p}\right] Q$$

$$K.E_\alpha = \frac{(A-4)m_p}{A\, m_p} . Q \Rightarrow \boxed{K.E_\alpha = \left(\frac{A-4}{A}\right) Q}$$

A → mass no. of X

## TYPES OF DECAY –

1) $\alpha$ – decay
2) $\beta$ – decay
3) $\gamma$ – decay

$\alpha$-Decay → $\quad {}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He + Q$ ($\alpha$-particle)

→ During $\alpha$-decay, the mass number decrease by 4 unit & atomic number decreases by 2 unit

| $\alpha$-particle
| is Nuclei of Helium
| (2p) (2n)
| → Positively charged

→ Q-value of the $\alpha$-decay →

$${}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He + Q$$

atomic mass → $M_X \quad M_Y \quad M_{He}$

Mass of Reactant = $[M_X - Zm_e]$ ← [illegible] Nucleus का mass चाहिए that's why mass of $e^-$ subtract किया।

mass of product = $[M_Y - (Z-2)m_e + m_{He} - 2m_e]$

$= [M_Y - Zm_e + 2m_e + m_{He} - 2m_e]$

Mass of product = $[M_Y - Zm_e + M_{He}]$

$\Delta m$ = mass of Reactant – mass of product

$\Delta m = [M_X - Zm_e] - [M_Y - Zm_e + M_{He}]$

$$\boxed{\Delta m = M_X - M_Y - M_{He}}$$

Q-Value = $(\Delta m)c^2$

Q-Value = $( m \quad M \quad M )c^2$

**Ques:-** Two atoms of X fuse together to form 1 atom of Y. If the B.E. of atom X is $E_1$ & B.E. of Y is $E_2$ then find out Q value of Rxn?

**sol:**

$$X + X \longrightarrow Y$$

$$E_1 \quad E_1 \quad E_2$$

~~(B.E)~~$_1$ Q-Value = $(B.E)_{Product}$ − $(B.E)_{React}$

$= \boxed{E_2 - 2E_1}$ Ans

**Ques:-** If two deuterium ($^2_1H$) fuse together & ($^4_2He$) Helium Nuclei is formed as —

$$^2_1H + ^2_1H \longrightarrow ^4_2He + Q\text{-Value}$$

Given that → B.E per Nucleon $^2_1H$ = 1.1 MeV
B.E per Nucleon $^4_2He$ = 7 MeV
Q-Value of Rxn = ?

**sol:** Q-Value = $(B.E)_{product} - (B.E)_{Reactant}$

~~for~~ But $\left(\frac{B.E}{A}\right)$ Given →

A/C to Question → B.E of $^2_1H$ = 1.1 × 2 = 2.2
B.E of $^4_2He$ = 7 × 4 = 28

Now → Apply the formula

Q-Value = 28 − (2.2 + 2.2)
= 28 − 4.4
= +23.6 MeV

MIRAJ

** Profile #03

$$P + Q \longrightarrow R + \text{Energy (Q-Value)}$$

Given B.E ⟶ $E_1$ — $E_2$ — $E_3$

Q value = ?

मतलब इस Ques. में Q-Value को in terms of B.E calculate करना है।

Sol:- AIPMT, AIIMS

$$\boxed{Q \text{ Value} = B.E_{product} - B.E_{Reactant}}$$

$$Q = [E_3] - [E_1 + E_2]$$

$$Q = E_3 - E_1 - E_2 \quad \text{Ans.}$$

PROOF ⟶

$$P + Q \longrightarrow R + Q\text{-value}$$

mass of Nuclei ⟶ $m_1$, $m_2$, $m_3$

$$Q\text{-Value} = [[m_1 + m_2] - m_3] c^2$$

$$\boxed{Q \text{ Value} = m_1 c^2 + m_2 c^2 - m_3 c^2}$$

$${}^{A_1}_{Z_1}P + {}^{A_2}_{Z_2}Q \rightarrow {}^{A_3}_{Z_3}R + Q \text{ value.} \qquad \left[\begin{matrix} A_1 + A_2 = A_3 \\ Z_1 + Z_2 = Z_3 \end{matrix}\right]$$

$$\left({}^{A_1}_{Z_1}P\right) \quad (B.E').(E_1) = [Z_1 m_p + (A_1 - Z_1) m_N - m_1] c^2$$

$$\Rightarrow E_1 = [Z_1 m_p + (A_1 - Z_1) m_N) c^2 - m_1 c^2$$

$$\Rightarrow m_1 c^2 = [Z_1 m_p + (A_1 - Z_1) m_N) c^2 - E_1$$

~~कुछ भी नहीं रहे।~~

$$Q\text{-value} = [Z_1 m_p + (A_1 - Z_1) m_N] c^2 - E_1 + (Z_2 m_p + (A_2 - Z_2) m_N) c^2 - E_2 - [(Z_3 m_p + (A_3 - Z_3) m_N) c^2] + E_3$$

$$= -E_1 - E_2 + E_3 = E_3 - (E_1 + E_2)$$

Ques:- In the following rxn: find out the energy released or Q value?

$${}^{1}_{1}H + {}^{3}_{1}H \longrightarrow {}^{2}_{1}H + {}^{2}_{1}H + \text{Energy Released (or Q value)}$$

Sol: Given ⇒ $m({}^{1}_{1}H) = 1.007825$ amu

$m({}^{3}_{1}H) = 3.019239$ amu

$m({}^{2}_{1}H) = 2.018765$ amu.

mass of Reactant $= 1.007825 + 3.019239 = 4.027064$

mass of product $=$ ~~2 × 2.0~~ $2.018765 + 2.018765 = 4.037530$

Energy released $= \Delta m \times 931.5$

$\Delta m =$ ~~4.027164 − 4.037530 = −1.923634~~ $= 4.037530 - 4.027064$

$\Delta m = -0.010466$ amu

$=$ ~~−1.923634 × 931.5~~

(∵ mass of product अधिक)

$B.E = -0.01 \times 931.5$

Q value $= -9.315$ MeV

⇓

(Endo)

⇓

ये Rxn. Spontaneous नहीं है

$^{15}_{17}Cl$

Sol: Theoretical mass $= Zm_p + (A-Z)M_n$

$= 17 \times 1.00785 + (35-17)1.008665$

~~= 17.13315 + 18.15970~~

$= 35.288995$ amu

$\Delta m$ = Theoretical − Observed

$= 35.288995 - 34.992350$

$\Delta m = 0.296645$ amu

$B.E = 0.296645 \times 931.5$

$= 0.30 \times 931.5$

$279.45$

$\frac{B.E}{A} = \frac{279.45}{35}$

$\frac{B.E}{A} = 7.99$ MeV per Nucleon.

Profile #02

Ques: $P + Q \longrightarrow R +$ Energy Released (Q Value)

$m_1 + m_2 \longrightarrow m_3$

masses of Nuclei (given)

Mass defect ($\Delta m$) = Masses of Reactants − Masses of Product

$$\boxed{\Delta m = [M_1 + m_2] - M_3}$$

$$\boxed{\text{Energy released (Q-Value)} = \Delta m \times 931.5 \text{ MeV}}$$

{ If Q value = +ve ⇒ Energy Released ⇓ Exothermic }

(Q) For the range –

$30 < A < 170$

⇓

$\frac{B.E}{A}$ is almost same

⇓

For large stable nuclei { Because each Nucleon is surrounded by fix no. of nuclei (under the range of Nuclear force)

∵ Nuclear force is a short ranged force.

**Some standard Profiles of Nuclear Physics →**

PROFILE #1 QUESTIONS:–

$^{A}_{Z}X$ observed mass $= M$

mass of each proton $= m_p$

mass of each Neutron $= m_N$

$\Delta m = ?$

$B.E = ?$

Sol. No. of proton $= Z$

No. of neutron $= A - Z$

Theoretical mass $= Zm_p + (A-Z)m_N$

$\Delta m =$ Theoretical mass – observed mass

$\Delta m = Zm_p + (A-Z)m_N - M$

$B.E = \Delta m (931.5)$ MeV

Ques: Find i) $\Delta m = ?$

ii) $B.E = ?$

iii) B.E per Nucleon i.e $\frac{B.E}{A} = ?$

Given $m_p = 1.007825$ amu

$m_n = 1.008665$ amu

observed mass of $^{35}_{17}Cl = 34.980$ amu

**NOTE:**

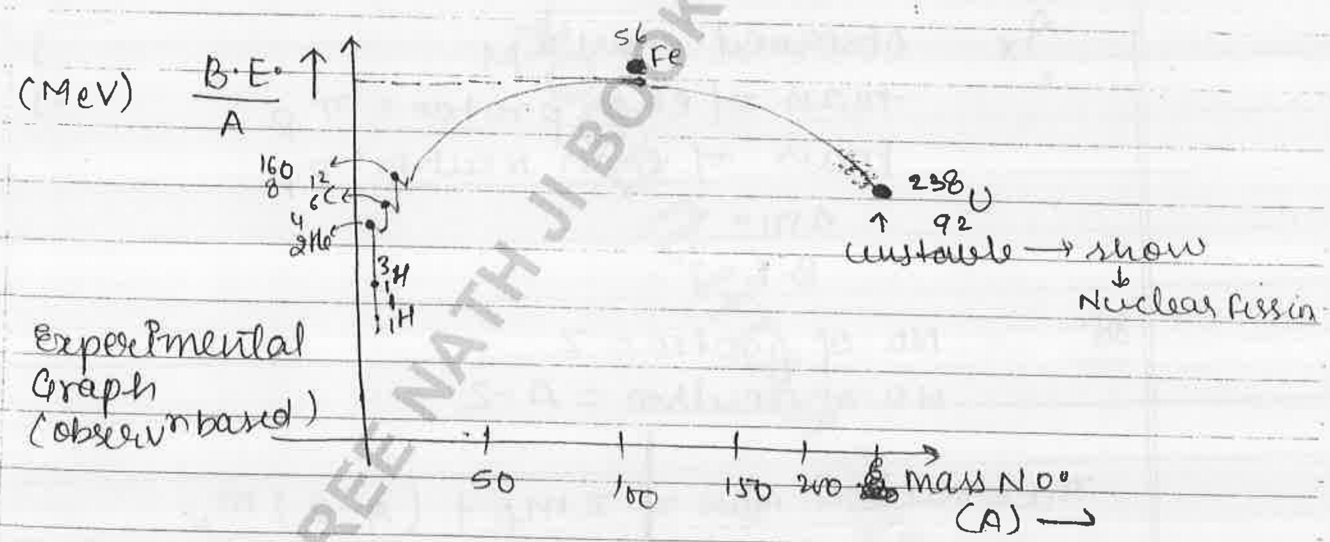
$^{56}Fe \rightarrow 492.8\ meV \quad \frac{B.E}{A} = \frac{492.8}{56} = 8.8\ meV$

$^{209}Bi \rightarrow 1640\ meV \quad \frac{1640}{209} = 7.46\ meV$

Criteria for stability ⇒ $\boxed{\frac{B.E}{A} = \frac{B.E}{\text{mass No.}} = \frac{B.E}{\text{Nucleon no.}}}$

(ज्यादा stability means ज्यादा $\frac{B.E}{A}$)

## Binding Energy for Nucleon curve:-




Features →

① $^{56}Fe \Rightarrow \frac{B.E}{A} \rightarrow$ सबसे ज्यादा (8.8 meV) ⇒ Highest stable Nuclei

② Heavy nucleus (A > 200) ⇒ $\frac{B.E}{A}$ → Low value → unstable → Break → (stable Nuclei)

③ $^{1}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He$ + Energy
Lighter Nuclei ⇒ Fuse ⇒ stable Nuclei

$\Delta m$ = mass defect = Theoratical − observed

$$\Delta m = [Zm_p + (A-Z)m_N] - M$$

अत: $B.E. = (\Delta m)c^2$

$$B.E = [Zm_p + (A-Z)m_N - M]\, c^2$$

कुछ भी नहीं रटो।

**Standard Note →**

Let $\Delta m = 1\,a.m.u = 1.66 \times 10^{-27}\,kg$

$B.E = (\Delta m)c^2$

$B.E = (1.66 \times 10^{-27})(3 \times 10^8)^2$

$B.E = 1.66 \times 10^{-27} \times 9 \times 10^{16}$ Joule

$$B.E = \frac{1.66 \times 10^{-27} \times 9 \times 10^{16}}{1.6 \times 10^{-19}}$$

$B.E = 931.5 \times 10^6\,eV = 931.5\,MeV$

Standard

$$1\,amu = 931.5\,MeV$$

**eg:** $\Delta m = 2.35$ amu

$B.E = 2.35\,(931.5)$ MeV

$\Delta m = 1.2937$ amu

$B.E = 1.2937\,(931.5)$ MeV

$\Delta m = 0.0093$ amu

$B.E = 0.0093\,(931.5)$ MeV

Theoratical mass = $8m_p + 8m_N$
(expected)
$= 8(1.007825) + 8(1.008665)$
$= 8.0626 + 8.06932$

Theoratical mass = 16.13192 amu.

↑

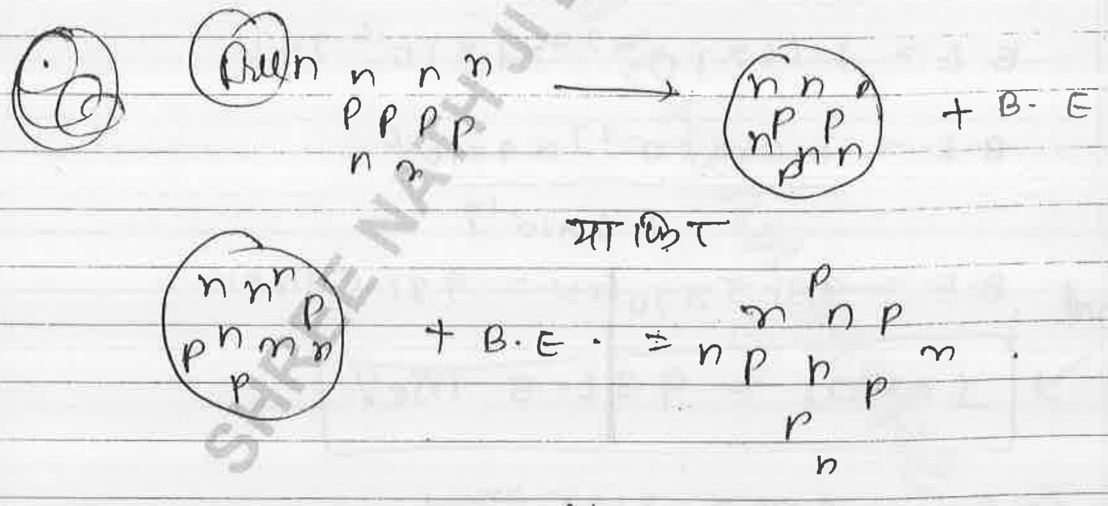
इसे expected mass भी कहा जाता है|

OBSERVED mass = 15.999353 amu

* $\boxed{B.E = \Delta m c^2}$ The energy corresponding to mass defect is known Binding Energy

$\Delta m$ → mass defect

$\Delta m$ = Theoritical mass − Observed mass




→ The energy required to break the Nuclei is to its constituents is known as B.E.

Note → $^A_Z X$, mass of each proton = $m_p$
mass of each Neutron = $m_N$
find $\Delta m$ = ?, B.E. = ?
Given Observed mass = M

Sol. No. of proton = Z
No. of Neutron = A − Z

Theo. mass = $Zm_p + (A-Z)m_N$

$\Delta m$ =

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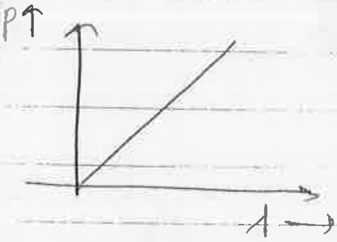
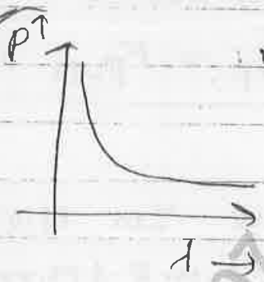
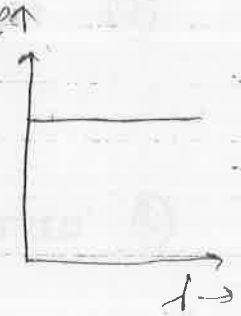
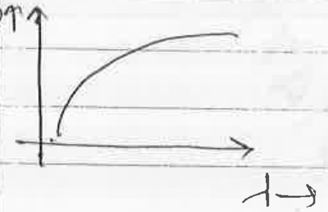
**Ques.** The correct graph b/w momentum & de-broglie wavelength is —

1) 

2) 

3) 

4) 

$\lambda = \frac{h}{p}$  $\boxed{\lambda \propto \frac{1}{p}}$

Rectangular Hyperbola

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**Ques.** If the radius of the nucleus of $^{27}Al$ is $R_{Al}$ then calculate the radius of $^{125}Te \Rightarrow R_{Te} = ?$

a) $\frac{3}{5} R_{Al}$

b) ✓ $\frac{5}{3} R_{Al}$

c) $\frac{2}{5} R_{Al}$

d) $\frac{5}{2} R_{Al}$

$\because R = R_0 (A)^{1/3}$

$\frac{R_{Al}}{R_{Te}} = \left(\frac{A_{Al}}{A_{Te}}\right)^{1/3}$

$\frac{R_{Al}}{R_{Te}} = \left(\frac{27}{125}\right)^{1/3}$

$\frac{R_{Al}}{R_{Te}} = \frac{3}{5} \Rightarrow R_{Te} = \frac{5 R_{Al}}{3}$ Ans.

## MASS DEFECT

$^{16}_{8}O$

$m_p = 1.007825$ amu & $m_N = 1.008665$ amu

No. of proton = 8

No. of Neutron = 8

## Properties → ( Nuclear Force )

① Independent of charge

$$\boxed{F_{p-p} = F_{p-N} = F_{N-N}}$$

② attractive In Nature

$r < 0.8$ fermi

⇓

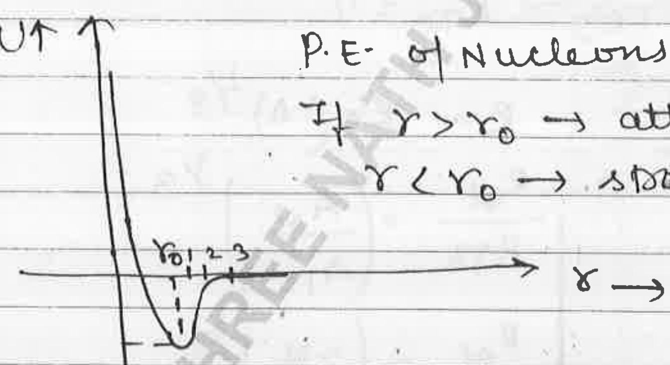
Repulsive

③ short Ranged

④ Coloumbic → $F = \frac{Kq_1q_2}{r^2}$

Gravity → $F = \frac{Gm_1m_2}{r^2}$

Nuclear → No simple mathematical formula

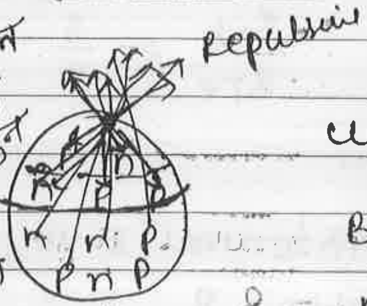



P.E. of Nucleons with distance r →

If $r > r_0$ → attractive

$r < r_0$ → strongly repulsive.

For Heavy Nucleus →




attract हो केवल Range तक हुए हैं, अर्थात् Repulsion Force सभी की ओर से

तो Rep. > attract

unstable

Break

unstable

⇓

Breaks

⇓

Radioactivity

eg: Uranium.

**NOTE:-** i) Density of all Nuclei is almost same and it is independent on mass number.

ii) The order of density of the nucleus is $10^{17} \frac{kg}{m^3}$.

**Ques:-** ** A nucleus which is at rest breaks into two parts and both parts have nonzero velocities and their Ratio of velocities is $\frac{v_1}{v_2} = \frac{1}{27}$; then find (i) Ratio of their masses. (ii) Ratio of Radii of their Nuclei

**Sol:** Conservation of momentum → (∵ Breaking हो रही)

(i) $m_1 v_1 = m_2 v_2$

$$\frac{m_1}{m_2} = \frac{v_2}{v_1} = \frac{27}{1} = 27:1$$

(ii) $R = R_0 (A)^{1/3}$ (const: $R_0$)

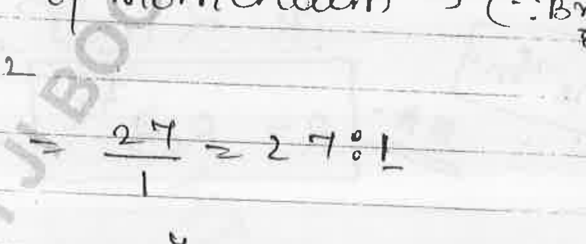
* जो Mass का Ratio होगा वही Mass No. का Ratio होगा।

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3}$$

$$\frac{R_1}{R_2} = \left(\frac{27}{1}\right)^{1/3} = 3:1$$

# NUCLEAR FORCE :-

Three types of force →




(1) Gravitation (weak) $= \frac{Gm_1m_2}{r^2}$

(2) Coulombic $F = \frac{q_1q_2}{r^2}$

(3) Nuclear Force

$m_{proton} \simeq m_{neutron}$

Density of all Nuclei is almost same.

Nuclear Group -

Isotope → elements having same Z.

eg: $^1_1H$, $^2_1H$, $^3_1H$

Isobar → Elements have same A.

Isotone → Elements having same A − Z.

## • SIZE OF NUCLEUS •

From several experiments, it is found that the radius of the Nucleus is given by →

$$R \propto (A)^{1/3}$$

1 fermi = $10^{-15}$ m.

** $$R = R_0 A^{1/3}$$

R → radius of Nuclei

A → mass No.

$R_0$ → constant = $1.2 \times 10^{-15}$ m.

= 1.2 fermi

Ques:- Calculate the Ratio of radii of two nuclei having mass no. in the Ratio of 1:27

Sol:

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} \Rightarrow \frac{R_1}{R_2} = \left(\frac{1}{27}\right)^{1/3} \Rightarrow R_1 : R_2 = 1 : 3$$

Ans.

** Ques:- The density of the Nucleus depends on mass Number as follows → (1) $\rho \propto A^1$ (2) $\rho \propto \frac{1}{A}$ (3) $\rho \propto A^0$ (4) None.

Sol:

$$\rho = \frac{m}{V} = \frac{A m_p}{\frac{4}{3}\pi R^3}$$

A = no. of neutron + no. of proton = 8

$$= \frac{A m_p}{\frac{4}{3}\pi (R_0 A^{1/3})^3} = \frac{A m_p}{\frac{4}{3}\pi R_0^3 A}$$

$$\rho = \frac{m_p}{\frac{4}{3}\pi R_0^3}$$

} constant, Independent of Area

(6)

# SECTION 'C' → NUCLEAR PHYSICS.

1) Nucleus was first discovered by scientist Rutherford by its α-scattering experiment

## COMPOSITION OF NUCLEUS :-


Proton ] → Nucleons
Neutron ]

| PROTON | NEUTRON |
|---|---|
| Charge = $+1.6 \times 10^{-19}$ C | charge = 0 |
| mass = $1.672 \times 10^{-27}$ kg | mass = $1.674 \times 10^{-27}$ kg<br>थोड़ा-सा ज्यादा होता है Proton से |

$^{A}_{Z}X$

Z → atomic no. (No. of protons)

A ⟶ mass no.
(No. of protons + no. of neutron)

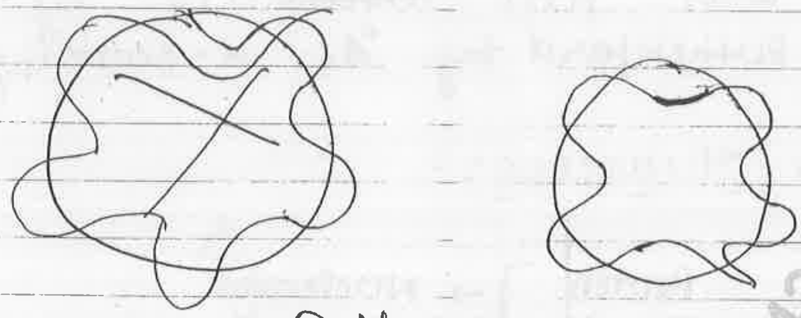
No. of Neutron = A − Z

eg: $^{16}_{8}O$ $\qquad$ $^{56}_{26}Fe$

No. of proton = 8 $\qquad$ No. of proton = 26

No. of Neutron $= 16 - 8 = 8$ $\qquad$ No. of Neutron $= 56 - 26 = 30$

# BOHR QUANTISATION EXPLAINED BY DE-BROGLIE

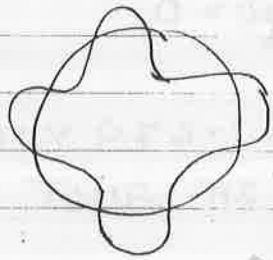


(CONSTRUCTIVE)

11th CHEM → Bohr model —

$$mvr = \frac{nh}{2\pi}$$

for 4th orbit ⇒



$$2\pi r = 4\lambda$$

आम ⇒ * $2\pi r = n\lambda$

$$2\pi r = n\left(\frac{h}{mv}\right) \Rightarrow mvr = \frac{nh}{2\pi}$$

— — — — — x — — — — —

Race Q.12

Ques. Calculate the % increase in mass of an electron accelerated by a potential diff. of 500 KV ?

Sol. 
$$\% \text{ change} = \frac{m - m_0}{m_0} \times 100$$

$$= \frac{mc^2 - m_0c^2}{m_0c^2} \times 100$$

$m_0c^2 \rightarrow 511$ (KeV)

$$= \frac{(511 + 500) - 511}{511} \times 100$$

$$= \frac{511 - 11}{511} \times 100 = \frac{500}{511} \times 100 \simeq 97.8\%$$

Race Q.14

Q.14. An $e^-$ & a photon have got the same debroglie wavelength. Prove that that the total energy of $e^-$ is greater than photon energy?

Sol.

| $e^-$ | Photon |
|---|---|
| $E_{Total} = m_e c^2$ | $E_{photon} = hc/\lambda$ |
| $E_{Total} = \frac{h}{\lambda v} c^2$ | $E_{ph} = \frac{hc}{\lambda}$ |

$\lambda = \frac{h}{m_e v}$, $m_e = \frac{h}{\lambda v}$

$$\frac{E_{e^-}}{E_{ph}} = \frac{\frac{h}{\lambda v} c^2}{\frac{hc}{\lambda}} \Rightarrow \frac{E_{e^-}}{E_{ph}} = \frac{c}{v}$$

$$\frac{E_{e^-}}{E_{ph}} > 1 \Rightarrow E_{e^-} > E_{ph}$$

$$E = mc^2$$

$$E = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \cdot c^2$$

Electron →

Rest mass $m_0 = 9.1 \times 10^{-31}$ kg.

Rest mass energy $E = m_0c^2 = 9.1 \times 10^{-31} [3 \times 10^8]^2$ Joule

$$E = \frac{9.1 \times 10^{-31} \times (3 \times 10^8)^2}{1.6 \times 10^{-19}} = 5.11 \times 10^3 \text{ eV}$$

$$E = 511 \text{ keV}$$

# पहले $m_0$ ✓

moving $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ ~~momen~~

Momentum.

$$p = mv$$

$$p = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \cdot v$$

wavelength → $\lambda = \frac{h}{mv} \Rightarrow \lambda = \frac{h}{\left(\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}\right) \cdot v}$

R/L b/w Total Energy & Momentum:-

रटो नहीं! solve it.

$$E_{Total} = \sqrt{m_0^2c^4 + p^2c^2}$$

(p → Momentum)

Note → From theory of relativity given by Albert Einstein we have →

$m \rightarrow$ variant

Rest mass $\rightarrow m_0$

moving mass →

$$* \boxed{m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}}$$

$m_0 \rightarrow$ Rest mass

$v \rightarrow$ speed of particle

$c \rightarrow$ speed of light

$m \rightarrow$ moving mass.

In case of Human beings :-

$v <<<<< c$

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \quad \left(\frac{v^2}{c^2} \rightarrow 0\right) \Rightarrow \boxed{m = m_0}$$

Que: कोई Body ~~कितनी~~ speed से चलें उसका mass, rest mass के double हो जाए?

Sol:

$v = ?$

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \Rightarrow 2m_0 = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$1 - \frac{v^2}{c^2} = \frac{1}{4} \Rightarrow 1 - \frac{1}{4} = \frac{v^2}{c^2} \Rightarrow v = \frac{\sqrt{3}}{2} c \quad \text{Ans.}$$

→ From Einstein mass energy equivalence, the total energy of the particle is given as —

$$* \boxed{E_{Total} = mc^2}$$

Rest mass $\rightarrow m_0$

moving mass $\rightarrow m = \dfrac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

Moving mass Energy ⇒

cylinder का परछाई → Rectangle
sphere ———————— → Circle

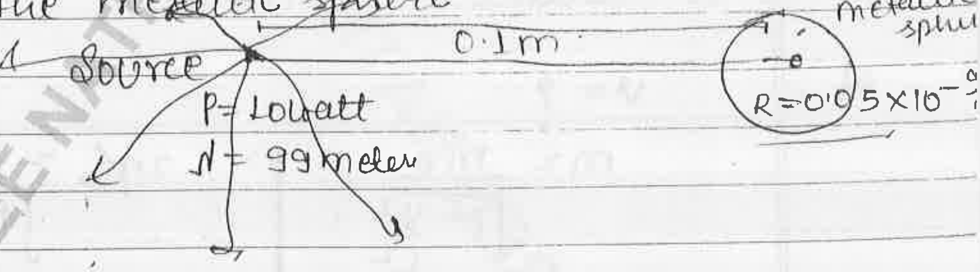
**Ques:-** A proton & α-particle enters in a uniform magnetic field and move in a circular orbits. If the radius of their orbits are same then find out the ratio of De-broglie wavelength ?

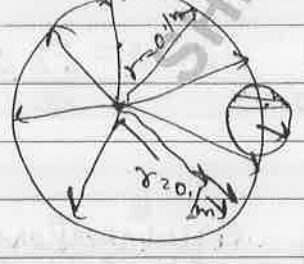
**Sol:-** $\lambda = \frac{h}{p}$ | $r = \frac{p}{qB} \Rightarrow p = qBr$

$\lambda = \frac{h}{qBr} \Rightarrow \lambda \propto \frac{1}{q}$

$\frac{\lambda_p}{\lambda_\alpha} = \frac{q_\alpha}{q_p} = \frac{2q_p}{q_p} = \boxed{2:1}$ Ans

**Ques:-** In the following calculate the no. of photons per sec incident on the metallic sphere.




$4\pi r^2 \longrightarrow P$

Unit $\longrightarrow \frac{P}{4\pi r^2}$

$\pi R^2 \longrightarrow \frac{P}{4\pi r^2}\pi R^2 \longrightarrow P'$

r = 0.1m.
R = 0.05×10^-

अब $\frac{N}{t} = \frac{P'\lambda}{hc}$

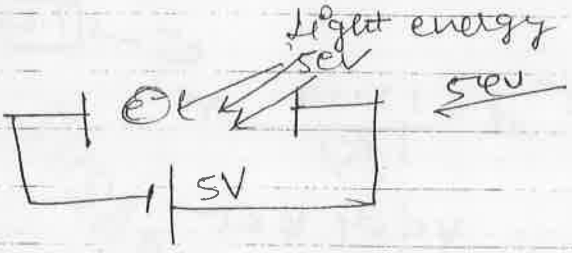
ex #02 $e^-$ को 50 volt से accelerate K.E = ?

sol$^n$ $K.E = qV \Rightarrow K.E = 1.6\times10^{-19}(50)$

K.E —— Joule

या फिर K.E = 50 eV

Que.

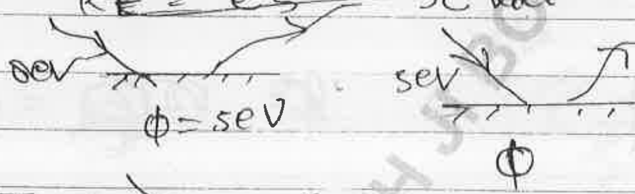



The photo e$^-$ ~~s~~ emitted have K.E 6eV to 8 eV then find the work function of the metal?

sol. हम तो already पढ़ चुके हैं।

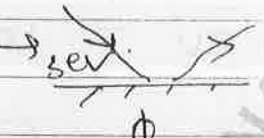
~~$K.E = qV$~~

~~$K.E = e5 = 5e$ Volt~~




$K.E_{max} = 5 - \phi$

नया क्या →



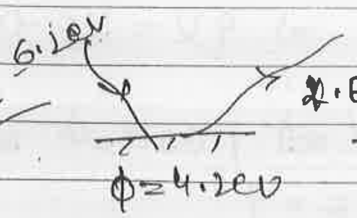

$K.E = 5 - \phi + 5$ ← due to battery i.e P.D.

$K.E_{max} = 10 - \phi$

acc to Question → $K.E_{max} = 10 - \phi = 8$

$\phi = 10 - 8 = 2eV.$

Page 92 Q.12 sol.




$K.E_{max} = 2 + 2 = 4$ eV. (2 By battery)

$K.E_{min} = 2 + 0 = 2eV$

$K.E_{max} = -5 - \phi$

$2 + 5 = -\phi$

$-3 =$

Page-132

Ex # 02 13, 16, 18, 21, 22,

Ex # 01 14

diffraction → $2d\sin\theta = n\lambda$ (Bragg's eqn) — Not in syllabus

⇓

$e^- \rightarrow$ 1.66 A°

De-broglie → $e^-$ $\lambda = \frac{12.27}{\sqrt{V}}$ A°

V = 54 Volt

$\lambda = \frac{12.27}{\sqrt{54}}$ $\lambda = 1.67$ A°

** अच्छे प्रश्न

Ques:- An $e^-$ have initial energy 100 eV & accelarated through a potential difference of 50 Volt. Calculate the debroglie wavelength associated with the $e^-$?

Sol: ~~$\lambda \neq \frac{12.27}{\sqrt{50}}$ ⇒ ...~~

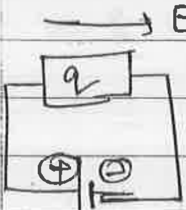
K.E पहले → 100 eV + 50 eV = 150 eV ∴ V = 150 V

$\lambda_e = \frac{12.27}{\sqrt{V}}$ A° ⇒ $\frac{12.27}{\sqrt{150}}$ ⇒ $\lambda = 1$ A°

⇓

Funda →

किसी charge particle को accelarate करना :-




$W_{electric\ field} = \Delta KE$ ⇒ $qV = KE - 0$ $K.E = qV$

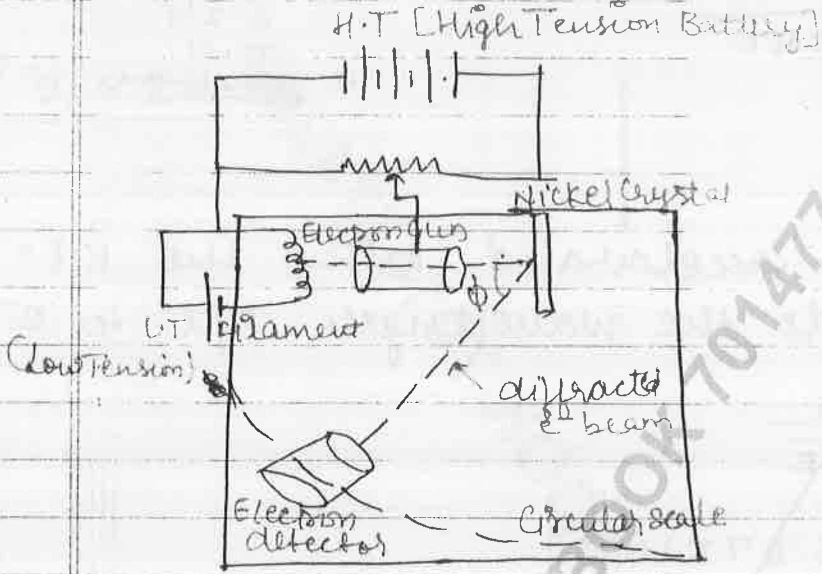
example #01 ~ $e^-$ को 1 Volt से accelar (start from rest) K.E = ?

Sol: $K.E = qV$ ⇒ $K.E = (1.6 \times 10^{-19})(1) = 1.6 \times 10^{-19}$ J

i.e ⇒ K.E = 1 eV

# DAVISSION - GERMER EXPERIMENT→

1) De-broglie hypothesis was verified by scientist davission & Germer.



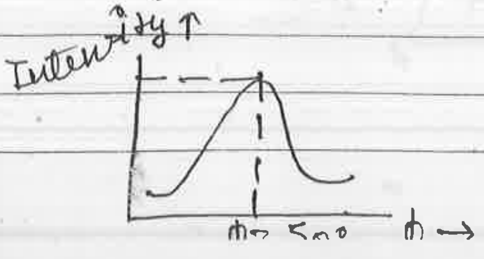



# Filament → produce e⁻. (Thermoionic experiment)

# Electron-accelaration → High Tension supply
(निकलने वाले e⁻ की speed बढ़ाना है ; applied P.D ↑)

# Nickel crystal → e⁻ beam का diffraction
(3D diffraction Grafting)

* 44 to 68 Voltage Vary किया -
at - V = 54 Volt
φ = 50° ⇒ Intensity → max^m



$\sqrt{5} = 2.23$ , $\sqrt{10} = 3.16$ , $\sqrt{2} = 1.414$ , $\sqrt{3} = 1.73$

7

**Ques.** An $e^-$ is accelarated with the potential difference of 50,000 Volt calculate the de broglie related to it?

**Sol.** $\lambda = \frac{12.27 \times 10^{-10}}{\sqrt{50000}}$ $\Rightarrow \lambda = \frac{12.27}{2.24} \times 10^{-12}$

$= ~~21.48~~ \; 5.4 \times 10^{-12}$ meter

Kilo volt

**Ques.** An $e^-$ is accelarated with the K.E. 100 keV then calculate the wavelength r/l to $e^-$?

**Sol.**

$\lambda = \frac{h}{\sqrt{mE}}$

$\lambda = \frac{6.67 \times 10^{-34}}{\sqrt{9.1 \times 10^{-31} \times 100 \times 1.6 \times 10^{-19}}}$

$\lambda = \frac{6.67 \times 10^{16}}{\sqrt{1456}}$ $= \frac{6.67 \times 10^{16}}{38}$

P.E. E ⇒
100 keV = K.E
V = 100 $\overset{10^3}{K}$Volt
= $10^5$ Volt

$\lambda = \frac{12.27}{\sqrt{V}} A^0$ $= \frac{12.27}{\sqrt{10.10^4}}$

$= \frac{12.27}{10^2 \sqrt{10}} A^0$

$\lambda = \frac{12.27}{10^2 (3.16)} A^0$

$\boxed{\lambda = 0.04 \, A^0}$ Ans

Unit का पैमाना →

$h = 6.67 \times 10^{-34}$ J. sec.

$v =$ m/sec

$m =$ kg

$\lambda =$ m

$5000 A^\circ = 5000 \times 10^{-10} m$

$4000 nm = 400 \times 10^{-9} m$

V → वोल्ट

$m = 10gm = 10 \times 10^{-3} kg$

q → coulomb.

(2) Standard Wavelength r/l to e

$$\lambda = \frac{h}{\sqrt{2mqV}} \Rightarrow h = 6.67 \times 10^{-34} \text{ J-sec}$$

$m = 9.1 \times 10^{-31}$ kg

$q = 1.6 \times 10^{-19}$ C

$$\lambda_{e^-} = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} V}}$$

$$\boxed{\lambda_{Electron} = \frac{12.27 A^\circ}{\sqrt{V}}}$$ → Potential Diff. (in Volt)

(3) Wavelength r/l to uncharged particle → (Neutron)

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$\lambda = \frac{h}{\sqrt{2m(\frac{3}{2}KT)}}$$

(Neutron) $$\boxed{\lambda = \frac{h}{\sqrt{3mKT}}}$$

XI th class →

$E = \frac{3}{2} KT$

T → Temperature (हमेशा Kelvin में)

K → Boltzmann's constant

$\lambda = \frac{h}{p}$

$r = \frac{p}{qB}$

$p = qBr$

p रखने →

$\lambda = \frac{h}{qBr}$

$\lambda = \frac{6.67 \times 10^{-34}}{(2 \times 1.6 \times 10^{-19}) \times 0.25 \times 0.83 \times 10^{-2}}$

$\lambda = 9.98 \times 10^{-13}$ metre

$\simeq 0.01 A^{0}$ Answer.



Que: A proton & deutron are accelarated through the same potential difference then calculate the ratio of de-broglie wavelength of the proton that of deutron?

Sol.

$\lambda = \frac{h}{\sqrt{2mqV}}$ ⇒ $\lambda \propto \frac{1}{\sqrt{mq}}$

$\frac{\lambda_p}{\lambda_D} = \sqrt{\frac{m_D q_D}{m_p q_p}} = \sqrt{\frac{2 \times q_p}{1 \times q_p}}$

$= \sqrt{2} : 1$ Ans.

Some Important points :-

(1) $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mqV}}$ ✓

Ques:- Calculate the momentum of the photon having wavelength 0.01 A°?

Sol:

$$\lambda = \frac{h}{p}$$

$$0.01 \times 10^{-10} = \frac{6.67 \times 10^{-34}}{p}$$

$$p = 6.67 \times 10^{-22} \ \frac{kg\, m}{sec}$$ A

Ques: An α-particle moves in a circular orbit of radius 0.83 cm in a magnetic field of 0.25 Tesla then calculate the debroglie wavelength related to α-particle. A

Sol.

$$r = \frac{mv}{qB}$$

$$0.83 \times 10^{-2} = \frac{4 \times v}{2 \times 1.6 \times 10^{-19} \times 0.25}$$

$$10^{-2} = \frac{10 v \times 10^{19}}{1.6}$$

$$6.25 v = 10^{17}$$

$$v = \frac{10 \times 10^{16}}{6.25} = 1.6 \times 10^{16}$$

$$\lambda = \frac{6.67 \times 10^{-34}}{\sqrt{2 \times 4 \times 1.6 \times 10^{-19} \times 1.6 \times 10^{16} \times 2}}$$

$$\lambda = \frac{6.67 \times 10^{-34}}{\sqrt{20.48 \times 10^{-3} \times 2}}$$

$$\lambda = \frac{6.67 \times 10^{-34}}{\sqrt{400 \times 10^{-4}}} = 6.67 \times 10^{-32}$$

NCERT solved ex.

**Que:** An $\alpha$-particle, proton and Deutron have same kinetic energy then which of them have shortest wavelength?

Sol.

$$\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}}$$

Proton → $m_p$
Deutron → $2m_p$
$\alpha$-particle → $4m_p$
↓
सबसे भारी

$$m_\alpha > m_D > m_p$$

$$\therefore \lambda_p > \lambda_D > \lambda_\alpha \leftarrow \text{shortest wavelength}$$

AIPMT-2012

**Que:** If the K.E. of the particle is increased by 16 times the calculate the % change in wavelength of the particle?

Sol.

$$\lambda_1 = \frac{h}{\sqrt{2mE}}$$

$$\lambda_2 = \frac{h}{\sqrt{2m \times 16E}} \Rightarrow \lambda_2 = \frac{h}{4\sqrt{2mE}} \Rightarrow \lambda_2 = \frac{\lambda_1}{4}$$

$$\% \text{ change} \Rightarrow \frac{\text{final} - \text{initial}}{\text{Initial}} \times 100$$

$$= \frac{\frac{\lambda_1}{4} - \lambda_1}{\lambda_1} \times 100$$

$$= -\frac{3}{4} \times 100 = -75\%$$

Means decrease by 75%

2

$$\boxed{p = mv} \quad \text{— (a)}$$

$$E = \frac{1}{2} m v^2$$

$$E = \frac{1}{2} \frac{m^2 v^2}{m} \quad \Rightarrow E = \frac{1}{2} \frac{p^2}{m}$$

$$= \boxed{p = \sqrt{2mE}}$$

If charge particle is accelarated from rest →

$$W_{electric\ field} = \Delta KE$$

$$qV = KE - 0$$

$$\boxed{K.E = qV}$$

w परिवार :-

***

$$\boxed{\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mqV}}}$$

(v → speed; p → Momentum; E → Energy; V → Potential difference)

Remember →

**α-particle**

$$m_\alpha = 4 m_{proton}$$

$$q_\alpha = 2 q_{proton}$$

**deutron**

$$m_D = 2 m_p$$

$$q_d = q_p$$

**Proton** $m_p$, $q_p$

Proton → $1.67 \times 10^{-27}$ kg

neutron → $1.674 \times 10^{-27}$ kg

α-particle → $4 (m_p)$

β → $e^-$ → $9.1 \times 10^{-31}$ kg

Section 'B'

# MATTER WAVES

Light → dual Nature → Wave Nature / Particle-Nature

→ Interference, diffraction, Polarisation → Wave Nature

→ Photoelectric, Compton effect, Pair Production → Particle Nature

In 1924 → Louis de Broglie imagined

material → Cricket Ball, You, moving Pen, electron, Proton → wave associate

De-Broglie Hypothesis →

$$\lambda = \frac{h}{p}$$ (p → momentum)

Davisson – Germer, Thomson ] experimentally proved de broglie

• "The wave which are associated with the material are known as matter waves".

Wavelength related to moving charge particle :-

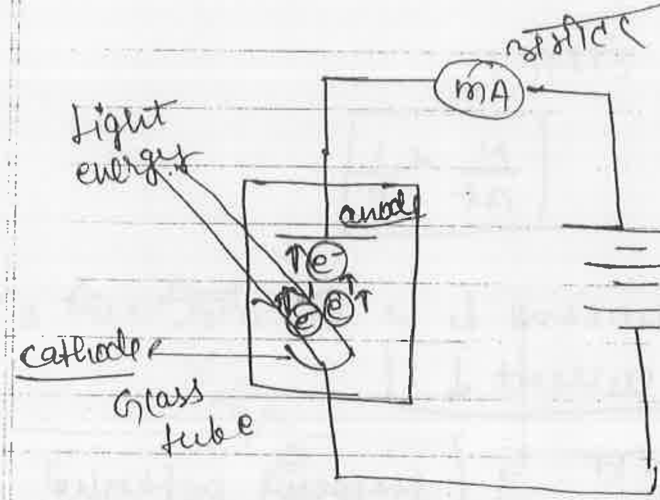
→ From de broglie hypothesis we know that

$$\lambda = \frac{h}{p} \quad \text{— (1)}$$

(λ → wave length, p → momentum)

Particle · mass → 'm'
speed → 'v'

PHOTO CELL [exclusive for Boards]




→ A device which convert light energy into electrical energy is k/as photo cell.

→ When light of energy greater than the work function ($\phi$) of the cathode incident on it, photoelectrons are emitted & current starts flowing.

---

**
Page 98
Q.13

$h\nu = \phi + K.E_{max} \Rightarrow \frac{hc}{\lambda} = \phi + \frac{1}{2}mv^2$ — (1)

3λ ⇒ $\frac{hc \times 4}{3\lambda} = \phi + \frac{1}{2}mv_1^2$

$\frac{4}{3}\left[\phi + \frac{1}{2}mv^2\right] = \phi + \frac{1}{2}mv_1^2$

$\frac{4}{3}\phi + \frac{4}{6}mv^2 = \phi + \frac{1}{2}m_1v^2$

$\frac{2\phi}{m} + \frac{4}{3}v^2 = v'^2$

$v' = \sqrt{\frac{4}{3}v^2 + \frac{2\phi}{3m}}$ Ans case #02

$\nu \uparrow$ ( I = constant )

क्या होगा।

sol: $I = \frac{Nh\nu}{At}$ $\boxed{\frac{N}{At} \propto \frac{1}{\nu}}$

$\nu \uparrow$ no. of photons ↓ → निकलने वाले $e^-$ की संख्या ↓

$\boxed{\text{current} \downarrow}$

मजे की बात → $\boxed{\text{stopping potential } V_0 \text{ बढ़ेगा}}$

case #03 Intensity, $\nu$ → double, क्या होगा।

sol: $I = \frac{Nh\nu}{At}$ ⇒ $2I = \frac{N'h(2\nu)}{At}$

$\boxed{N' = N}$

आने वाले photons की संख्या → वही

electron → वही।

$\boxed{\text{current} \to \text{constant}}$

→ $\boxed{\text{stopping potential} \to \text{बढ़ेगा}}$

more than double

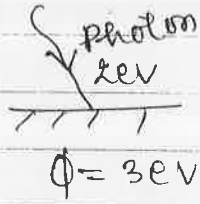
## Golden Key Points Regarding Photoelectric Effect →

① Einstein photoelectric equation is based on law of conservation of energy.

② P.E.E varify the particle nature of Light.

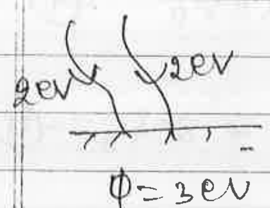
③ P.E.E. is an instanteneous process i.e there is no time lag (अंतर) b/w incidence of photons & ejection of electrons.

④ ** 'AIIMS' A/C to Einstein one photon can interact with the one $e^-$ only.




~~P.E.E~~

$\phi = 3eV$




~~P.E.E~~

$\phi = 3eV$

**ONE PHOTON ⟶ ONE ELECTRON**

$\therefore$ Intensity = $\frac{Energy}{area\ time} = \frac{Nh\nu}{At}$

*** ⑤ Case #01

Intensity ↑
($\nu$ = constant)

क्या होगा ?

Sol: $I = \frac{Nh\nu}{At} \Rightarrow I \propto \frac{N}{At} \propto$ no. of photons coming per unit area per unit time.

Intensity ↑
आने वाले → No. of photon ↑
ejected $e^-$ की संख्या ↑
Current ↑

$V_0 \rightarrow$ Same ($\because \nu$ const)

Imp ← इसलिए K.E. बदल है

Stopping potential सिर्फ frequency पर depend करता है।

$K.E = eV_0$

AIPMT-2015 page-92 Q.10 Q.15 (Set-D)

Que- A certain metallic surface is illuminated with the monochromatic light of wavelength $\lambda$, the stopping potential for this light is '$3V_0$'.

If the same surface is illuminated with the light of wavelength $2\lambda$, the stopping potential is $V_0$. Then calculate the threshold wavelength for the surface?

(1) $4\lambda$
(2) $\lambda/4$
(3) $\lambda/6$
(4) $6\lambda$

Sol:
$$\frac{hc}{\lambda} = \phi + 3eV_0$$
(same surface)
$$3 \times \left(\frac{hc}{2\lambda} = \phi + eV_0\right) \quad \text{-(II)}$$

$$\frac{hc}{\lambda} = \phi + 3eV_0 \quad \text{-(I)}$$
$$\frac{3hc}{2\lambda} = 3\phi + 3eV_0 \quad \text{-(II)}$$
$$\ominus$$
$$-\frac{hc}{2\lambda} = -2\phi$$

$$\Rightarrow \frac{hc}{2\lambda} = 2\left[\frac{hc}{\lambda_0}\right] \Rightarrow \frac{1}{2\lambda} = \frac{2}{\lambda_0} \Rightarrow \lambda_0 = \boxed{4\lambda}$$

Also see Q.9, Q.18

Que- If the frequency of incident radiations gets doubled then how does the max$^m$ K.E. of the ejected $e^-$ changes -
i) doubled
ii) Remain same
iii) Half
iv) More than double

Sol:
$$h\nu = \phi + K.E_{max1} \quad \text{-(1)}$$
$$2h\nu = \phi + K.E_{max2}$$
(1) ÷ (2)
$$\frac{1}{2} = \frac{\phi + K.E_{max1}}{\phi + K.E_2}$$
$$\phi + K.E_2 = 2\phi + K.E_1$$
$$K.E_2 = 2KE_1 + 2\phi - \phi \longrightarrow \boxed{K.E_2 = 2K.E_1 + \phi}$$

AIPMT-2014

**Ques:-** Light with the intensity $25 \times 10^4 \frac{watt}{m^2}$ falls on a perfectly reflecting surface at normal incidence. If the surface area is $15 \times 10^{-4} m^2$ then calculate the force exerted on the surface.

i) $1.25 \times 10^{-6}$ N
ii) $2.5 \times 10^{-6}$ N ✓
iii) $1.20 \times 10^{-6}$ N
iv) $3 \times 10^{-6}$ N

Sol:- (Case of परावर्तन)

$$F = \frac{2P}{C}$$

$$P = \text{Intensity (Area)}$$
$$= 25 \times 10^4 \times 15 \times 10^{-4}$$
$$= 375 \text{ watt}$$

$$F = \frac{2 \times 375}{3 \times 10^8} = 250 \times 10^{-8}$$
$$= 2.50 \times 10^{-6} \text{ N Ans.}$$

3 may) AIPMT-2015

**Ques:-** A radiation of energy 'E' falls normally on a perfectly reflecting surface. The momentum transferred to the surface is — $p = \frac{E}{C}$

i) $\frac{2E}{C}$ ✓
ii) $\frac{2E}{C^2}$
iii) $\frac{E}{C^2}$
iv) $\frac{E}{C}$

Sol:- आते समय Momentum

$$\text{Initial} = \frac{E}{C}(-\hat{j})$$

$$\text{Final Mom.} = \frac{E}{C}(+\hat{j})$$

$$\Delta\vec{p} = \frac{E}{C}(+\hat{j}) - \frac{E}{C}(-\hat{j})$$

$$\Delta\vec{p} = \frac{2E}{C}\hat{j}$$

$$|\Delta\vec{p}| = \frac{2E}{C} \text{ Ans.}$$

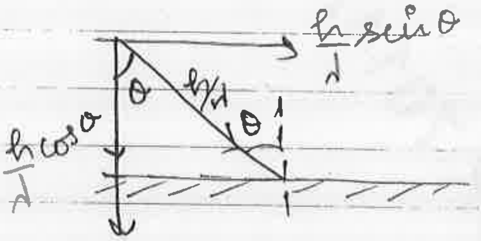
Power = Intensity area

$$F = \frac{I[A]}{C}$$

$$\frac{F}{A} = \frac{I}{C}$$

$$\boxed{\text{Pressure} = \frac{I}{C}}$$

Case #03 Photon Incidence on some angle (tilted)



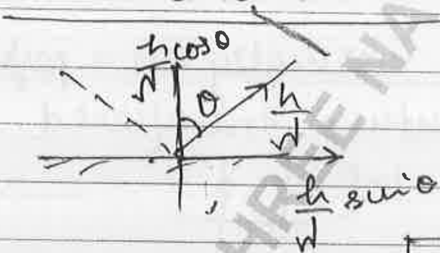

100% Reflecting surface

Initial Momentum →

$$\vec{p_i} = \frac{h}{\lambda}\cos\theta(-\hat{j}) + \frac{h}{\lambda}\sin\theta(+\hat{i})$$

Final Momentum →

$$\vec{p_f} = \frac{h}{\lambda}\cos\theta(+\hat{j}) + \frac{h}{\lambda}\sin\theta(+\hat{i})$$




$$\Delta\vec{p} = \frac{2h}{\lambda}\cos\theta(+\hat{j})$$

$$\boxed{|\Delta p| = \frac{2h}{\lambda}\cos\theta}$$

$$\frac{N}{t} = \frac{P\lambda}{hc}$$

Total change in Momentum / sec $= \frac{P\lambda}{hc}\,\frac{2h\cos\theta}{\lambda}$

$$\boxed{F = \frac{2P\cos\theta}{C}}$$

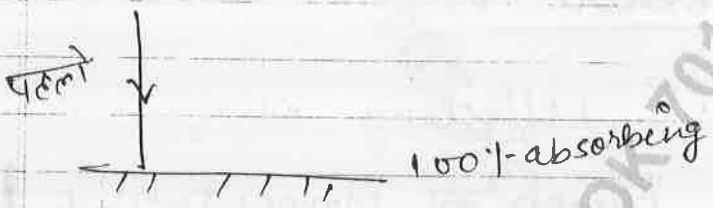
Power = Intensity (Area)

$$F = \frac{2[I \cdot A]}{C}$$

$$\frac{F}{A} = \frac{2I}{C}$$

$$\boxed{\text{Pressure} = \frac{2I}{C}}$$

case #02 100% absorbing Surface →




Initial momentum $= \frac{h}{\lambda}(-\hat{j})$

Final $= 0$

change in momentum $\vec{\Delta p} = \vec{P_f} - \vec{P_i}$

$$= 0 - \frac{h}{\lambda}(-\hat{j})$$

$$\vec{\Delta p} = \frac{h}{\lambda}\hat{j}$$

$$\boxed{|\Delta p| = \frac{h}{\lambda}}$$ ← change in momentum

$$\frac{\text{No. of photon}}{\text{sec}} = \frac{P\lambda}{hC}$$

$$\frac{\text{Total change in momentum}}{\text{sec}} = \frac{h}{\lambda}\frac{P\lambda}{hC}$$

$$\frac{\vec{\Delta p}}{\Delta t} = \frac{P}{C}$$

$$\boxed{F = \frac{P}{C}}$$ ← Power

→ Thresold ~~Frequency~~ wavelength → जिसके ऊपर Photoelectric effect नहीं होगा।

example ⇒ U.V. rays → P.E.E ✗

यहाँ → X-ray → P.E.E ✓

Infra, micro ] P.E.E नहीं होगा। UV से ऊपर है।

## Radiation Pressure :-

case #01  100% Reflecting surface


Photon का Momentum $\boxed{p = \frac{h}{\lambda}}$

Initial momentum (पहले) $= \frac{h}{\lambda}(-\hat{j})$

बाद

Final Momentum $= \frac{h}{\lambda}(+\hat{j})$

change in momentum $\vec{\Delta p} = \vec{P_f} - \vec{P_i}$

$= \frac{h}{\lambda}(+\hat{j}) - \frac{h}{\lambda}(-\hat{j})$

$\vec{\Delta p} = \frac{2h}{\lambda}\hat{j}$ ✓ $\boxed{|\Delta p| = \frac{2h}{\lambda}}$ → change in momentum

$\frac{\text{No. of photons}}{\text{sec}} = \frac{P\lambda}{hc}$

$\frac{\text{Total change in momentum}}{\text{per sec}} = \left(\frac{2h}{\lambda}\right)\left(\frac{P\lambda}{hc}\right)$

Newtons IInd → $\frac{\Delta p}{\Delta t} = \frac{2P}{c} \Rightarrow \boxed{F = \frac{2P}{c}}$ ← Power

Electro magnetic Spectrum :-
(detailed in chapter - EM waves)

| | | |
|---|---|---|
| NCERT | Radio waves | $\lambda > 0.1$ metre |
| | Micro wave | 0.1m to 1mm |
| | Infra-red | 1mm to 700nm |
| ऊपर से नीचे wavelength घटती है | Light (Visible) | 700nm to 400nm |
| | Ultra-violet | 400nm to 1nm |
| | X-Ray | 1nm to $10^{-3}$ nm |
| | Gamma rays | $< 10^{-3}$ nm |

{ $\phi_{min} \to Cs \to 2.1 eV$
$\phi_{max} \to Pt \to 5.6 eV$ }

Ex 701 Q.24

$\phi = 6.2 eV$

$E = \phi + K.E_{max}$

$\frac{hc}{\lambda} = 6.2 + 5 eV$

$\frac{12400 \times 10^{-10}}{\lambda} = 6.2 + 5$

$\lambda = \frac{12400 \times 10^{-10}}{11.2}$

$\lambda = 11.0 \times 10^{-10}$

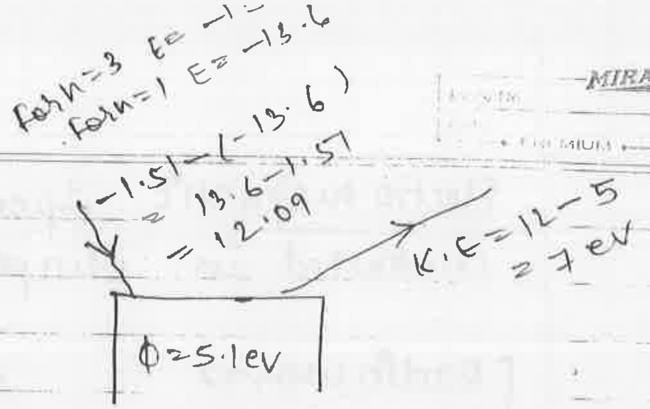
$\lambda = 110$ nm

i.e Ultraviolet

Ex #01

20

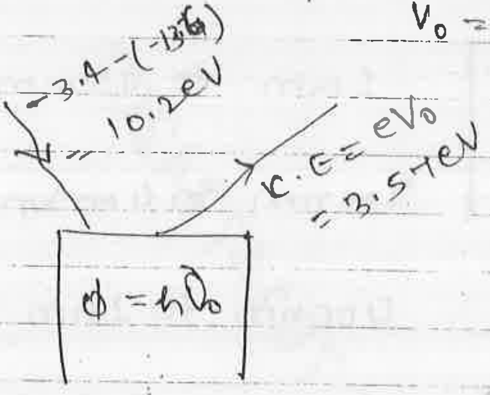
$\phi = 5.1\,eV$




~~$eV_0$~~ $V_0 = 7$ ~~$e$~~$V$

$V_0 = 7\,Volt$

36




~~$e$~~$V_0 = eV$

~~$V_0$~~ $= V_0 = 3.57\,V$

$E = \phi + K.E_{max}$

$10.2 = \phi + 3.57$

$\phi = 6.63\,eV$

~~$\phi = 10.2 + 3.57\,eV$~~

~~$= 13.77\,eV$~~

~~$\phi = h\nu_0$~~ $\Rightarrow$ ~~$\frac{13.77}{1.6\times10^{-19}} = 6.6\times10^{-34} \times \nu_0$~~

~~$\frac{8.6\times10^{-19}}{6.6\times10^{15}} = \nu_0$~~

$6.63 \times 1.6 \times 10^{-19} = h\nu_0$

$6.63 \times 1.6 \times 10^{-19} = [6.63 \times 10^{-34}]\,\nu_0$

$\nu_0 = \frac{1.6\times10^{-19}}{10^{-34}}$

$= 1.6 \times 10^{15}$

# Some Important points Regarding Atomic structure :~ (XI chem.)

(स्पष्ट observed)

## Hydrogen spectrum

$\frac{n(n-1)}{2}$ = No. of wavelengths

n = Higher transition state

से। −0.85 eV ———— n=4

−1.51 eV ———— n=3

−3.4 eV ———— n=2

−13.6 eV ———— n=1

~~I.E. =~~ $\frac{-13.6 Z^2}{n^2}$ eV   [ $I.E. = \frac{-13.6 n^2}{Z^2}$ eV ]

Hydrogen → Z = 1

$T.E. = \frac{-13.6}{Z^2}$

**electron.** Higher → lower
Energy → Release → Photon

For Hydrogen

eg. n=4 से n=1

$E = -0.85 - (-13.6)$

$E = 12.75 eV$

3rd excited to Ground.

n = 2 से n=1

First excited to Ground

$E = -3.4 - (-13.6)$

$E = 10.2 eV$ ~~का Photon~~ ~~पैदा~~ होगा।

Page No.
Date:

Ex 2 (5) Calculation

$h\nu = \phi + K.E_{max}$

$\frac{hc}{\lambda} = \frac{hc}{2300 \times 10^{-10}} + K.E_{max}$

$\frac{hc}{1800 \times 10^{-10}} = \frac{hc}{2300 \times 10^{-10}} + K.E_{max}$

$K.E_{max} = 10^{8} \times hc \left[ \frac{1}{18} - \frac{1}{23} \right]$

$K.E_{max} = 10^{8}\, hc \left[ \frac{5}{394} \right]$

$= \frac{10^{8} \times 6.67 \times 10^{-34} \times 3 \times 10^{8} \times \frac{1}{40}}{1.6 \times 10^{-19}}$ eV

$= \frac{4.1 \times 3}{40} \times 10^{8} \times 10^{-15} \times 10^{8}$

$= \frac{12.3}{4.04} \times 10 =$

Ans $= 1.5$ eV.

(4) Unit का पंगा →

$\phi = h\nu_0$

$\phi \rightarrow$ Joule

$\nu_0 \rightarrow Hz$ ✓

$1 eV = 1.6 \times 10^{-19} J$

$3.3 eV = 3.3 \times 1.6 \times 10^{-19}$ Joule

$h\nu = \phi + K.E_{max}$

पूरा Joule में या eV

Pg - 96

Q.39 $h\nu = \phi + K.E_{max}$ $\phi = h\nu_0$

~~$6.67 \times 10^{-34}$~~ $h \times 1 \times 10^{14} = h \times 5 \times 10^{13} + K.E$

$10^{14} h = 5h \times 10^{13} + K.E_{max}$

$K.E_{max} = 10^{14} h - 5 \times 10^{13} h$

$= 10^{13} h (10 - 5)$

$= 5 \times 10^{13} h$

$= 5 \times 6.67 \times 10^{-34} \times 10^{13}$

$= 34.55 \times 10^{-21}$

$= 3.3 \times 10^{-20}$ Joule

Q.34 $h \times 8.2 \times 10^{14} = h \times 3.3 \times 10^{14} + K.E_{max}$

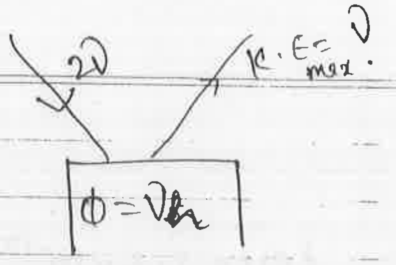
(Calculation गलत)

$K.E_{max} = h \times 10^{14} (5)$

$= 6.67 \times 10^{14} \times 5 \times 10^{34}$

$= 3.4 \times 10^{14} \times 10^{34}$

$V_0 = \frac{3.4 \times 10^{14} \times 10^{34}}{1.6 \times 10^{-19}} = 2 \times$



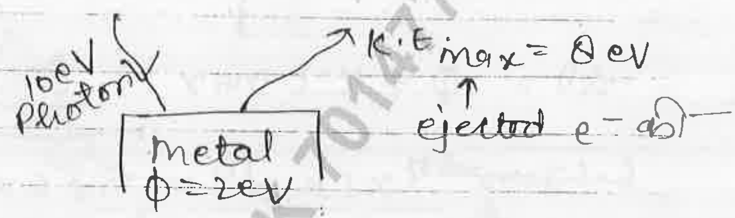

$$\frac{1}{2}mv^2 = \nu h$$
$$v^2 = \frac{2\nu h}{m}$$
$$v = \sqrt{2\nu h/m}$$
$$v = \sqrt{2h\nu/m}$$ **Ans**

Thresold frequency = ν

work function = hν

## PHOTOELECTRIC EFFECT REVISITED :-

① Basic funda




② अगर हमे K.E max पता है -

तुरन्त $V_0$ पता किया जा सकता है ।

$K.E_{max} = 5eV \longrightarrow V_0 = 5$ Volt

$K.E_{max} = 3.57\,eV \longleftarrow V_0 = 3.57$ Volt

③ शानदार $\boxed{h\nu = \phi + K.E_{max}}$ → क्या है?

आने वाली Photon की energy

$E = h\nu$ (Joule)

$E = \frac{hc}{\lambda}$ (Joule)

$E = \frac{12400 \times 10^{-10}}{\lambda}$ eV

λ ↓ मीटर मे

φ क्या है ।

φ = workfunction

$\phi = h\nu_0$

$\phi = \frac{hc}{\lambda_0}$

$\phi = \frac{12400 \times 10^{-10}}{\lambda_0}$ eV

$K.E_{max} = eV_0$

$K.E_{max} = \frac{1}{2}mv_{max}^2$

(4) Einsteen eqn

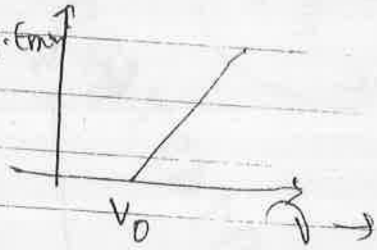
$$h\nu = \phi + K.E_{max}$$

(5) Intensity ↑ ($\nu$ = constant)

⇓

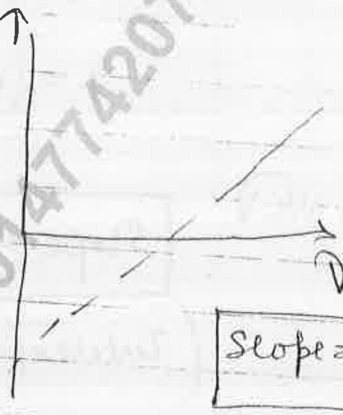
Current ↑

(6)



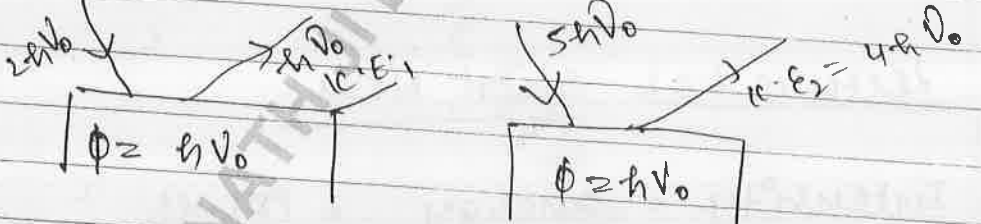

Slope = h

(K.E = -ve नहीं हो सकती)




Slope = $\frac{h}{e}$

Module Pg-94 Q#16




$$\frac{K.E1}{K.E2} = \frac{h\nu_0}{4h\nu_0} = \frac{1}{4} = \frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2}$$

$$\frac{v_1}{v_2} = \frac{1}{2} \Rightarrow \frac{4\times10^6}{v_2} = \frac{1}{2}$$

$$v_2 = \underline{8\times10^6 \text{ m/s}}$$

② $V_0$ v/s Frequency curve :-
from ①

$$K.E_{max} = h\nu - h\nu_0$$

$$\Rightarrow eV_0 = h\nu - h\nu_0$$

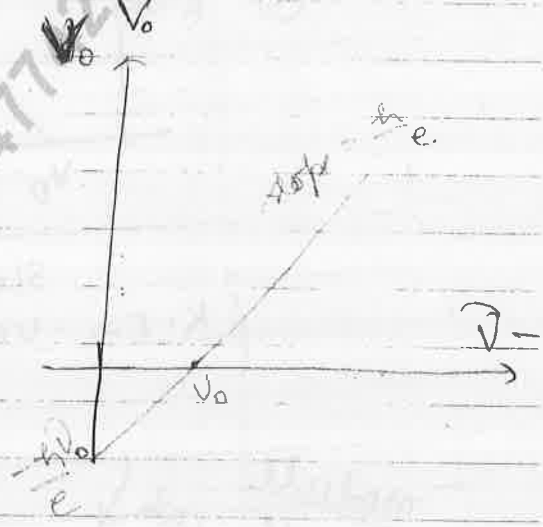
$$V_0 = \frac{h\nu}{e} - \frac{h\nu_0}{e}$$

$$y = mx + c$$

$V_0$ v/s $\nu$

**Slope = $\frac{h}{e}$**

(Intercept = $-\frac{h\nu_0}{e}$)

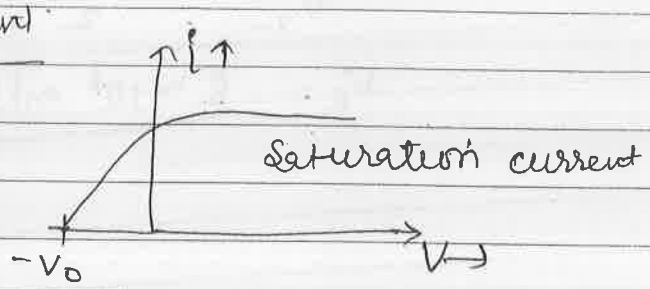



## Lecture #02 Short Notes

① Intensity = $\frac{\text{energy}}{\text{Area time}}$ = $\frac{\text{Power}}{\text{Area}}$

② Point source ⇒ $I \propto \frac{1}{(\text{distance})^2}$

③ Experiment




④ $K.E_{max} = eV_0$   K.E max 4eV . $V_0$ 4 Volt

⑤ .

Page 93
Q.5

6 आया 4 निकालने मे खर्च (i.e work functio

$\therefore$ K.E max = 2 eV

Page-94
Q.20

4 आई 2 work function

K.E max = 2eV

K.E max = $eV_0$

$2eV = eV_0 \Rightarrow V_0 = 2$ volt

Page-96
Q.33

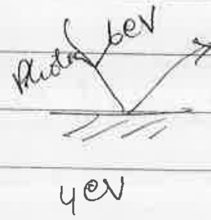
K.Emax = 0.5 eV

$\phi = 1.8$ eV

(K.Emax हो तो $V_0$ है)

0.5 volt

Ex#02
Q-6




K.Emax = 4eV

$V_0 = 4$ Volt

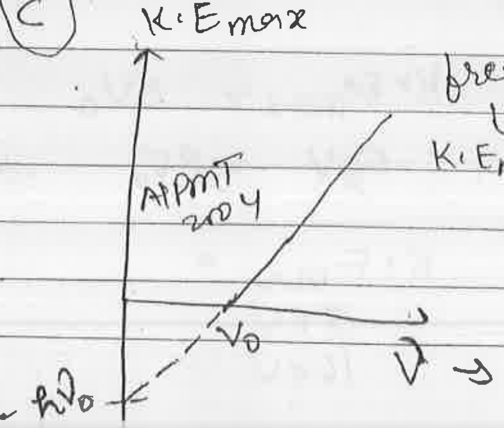
## SOME IMPORTANT GRAPHICAL CONCEPTS:-

(1) $h\nu = \phi + K.E_{max} \Rightarrow h\nu = h\nu_0 + K.E_{max}$

(I) $\Rightarrow K.E_{max} = h\nu - h\nu_0$

तुलना $\Rightarrow y = mx + C$

constant (Slope = $h$
Intercept = $-h\nu_0$)




frequency ↑
⇓
K.Emax बढ़ती

(5)

Ex 10.1 Q.22 & Q.10 same profile

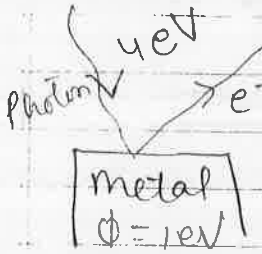
0.5 m —दूरी→ 1.0 m

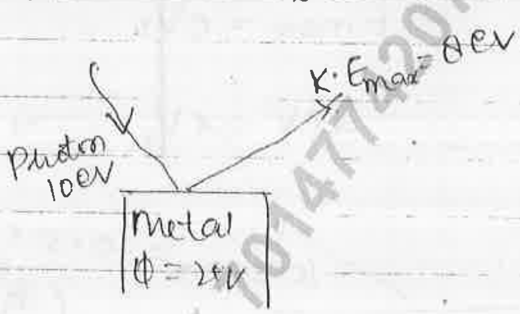
दुगुनी → I → $\frac{1}{4}$

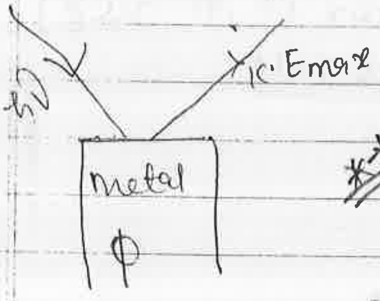
तो Photon भी $\frac{1}{4}$

Most Imp ******

## ·EINSTEIN PHOTOELECTRIC EQUATION·



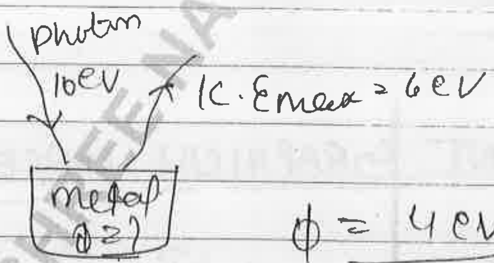




** $h\nu = \phi + K.E._{max}$

→ follows conservation of Energy

example




$\phi = 4eV$

Que: If the max$^m$ K.E. of the ejected $e^-$ is 5eV then find out the stopping potential or reverse potentie

Sol: $K.E_{max} = eV_0$

$5eV = eV_0 \Rightarrow V_0 = 5$ Volt

Or

| K.Emax | $V_0$ |
|---|---|
| 5 eV | 5 Volt |
| 16 eV | 16 Volt |

**Observation #02

Intensity → double ($\nu$ = constant)

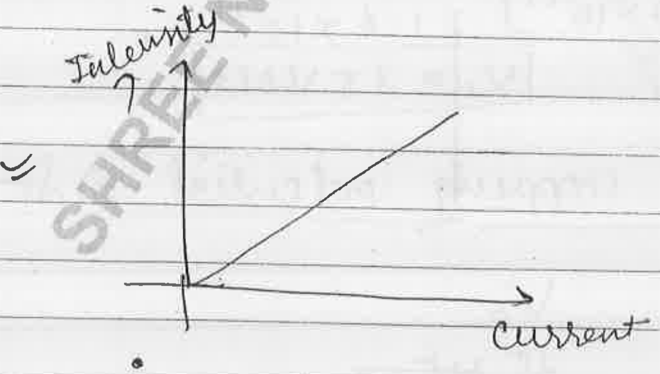
$$I = \frac{\text{Energy}}{\text{Area}\cdot\text{time}}$$

$$I = \frac{N(h\nu)}{At}$$

($I \propto \frac{N}{At} \propto$ no. of photon per unit area per unit time)

Intensity ↑ ($\nu$ = const)
⇓
आने वाले no. of photon per unit area per unit time ↑
⇓
निकलने वाले $e^-$ की संख्या ↑
⇓
Photoelectric current ↑

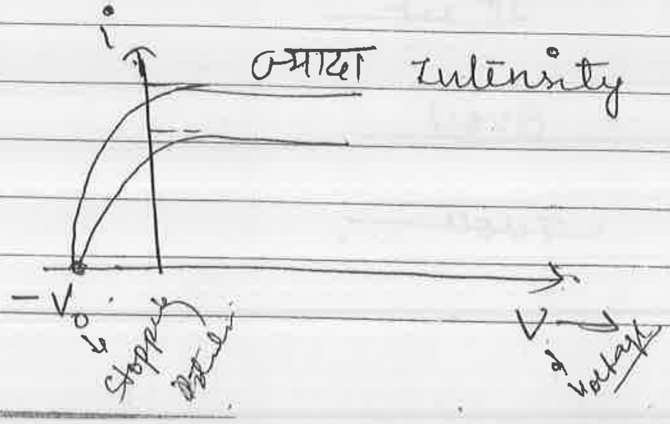
परन्तु ⇒ ($V_0$ वही रहेगा)




अलग से
$i_{saturation} \propto$ Intensity

$$\left(\frac{i_{s1}}{i_{s2}} = \frac{I_1}{I_2} = \left(\frac{d_2}{d_1}\right)^2\right)$$

(→ $V_0$ is independent of distance & Intensity)



Stopping Potential → The minimum (-ve) potential for which photoelectric current in the circuit becomes zero is known as stopping potential and it is represented by $V_0$.

→ Stopping potential is always related to maxm Kinetic Energy of the ejected electron.

$$W = \Delta K.E.$$

$$-eV_0 = 0 - K.E_{max}$$

$$\boxed{K.E_{max} = eV_0}$$

JKY sir
$V = \frac{W}{q}$
$W = eV$

Ques. If the maxm K.E. of the free $e^-$ is 15 eV then find out the ~~maxm~~ stopping potential.

Sol.

$K.E_{max} = eV_0 \Rightarrow 15\, eV = eV_0$

$\boxed{V_0 = 15\ \text{volt}}$

method #02 $(\because e = 1.6 \times 10^{-19})$

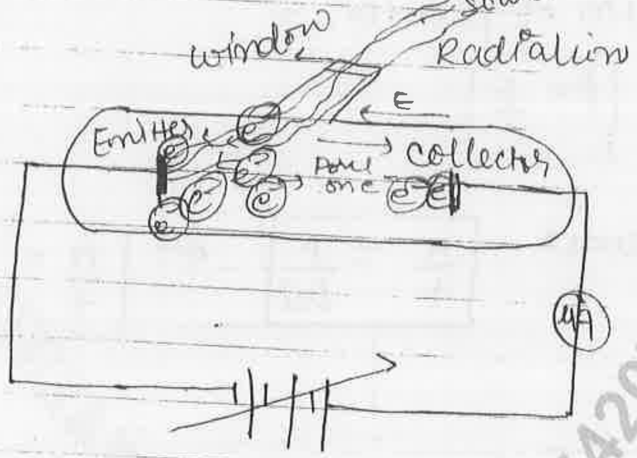
$15\,[1.6 \times 10^{-19}] = 1.6 \times 10^{-19}\, V_0$

$\boxed{V_0 = 15\ \text{volt}}$

* K.E max और stopping potential होती है।

| K.E max | $V_0$ |
|---|---|
| 15 eV | 15 volt |
| 8 eV | 8 volt |
| 7 eV | 7 volt |

# Experimental setup (Hertz & Lenard).

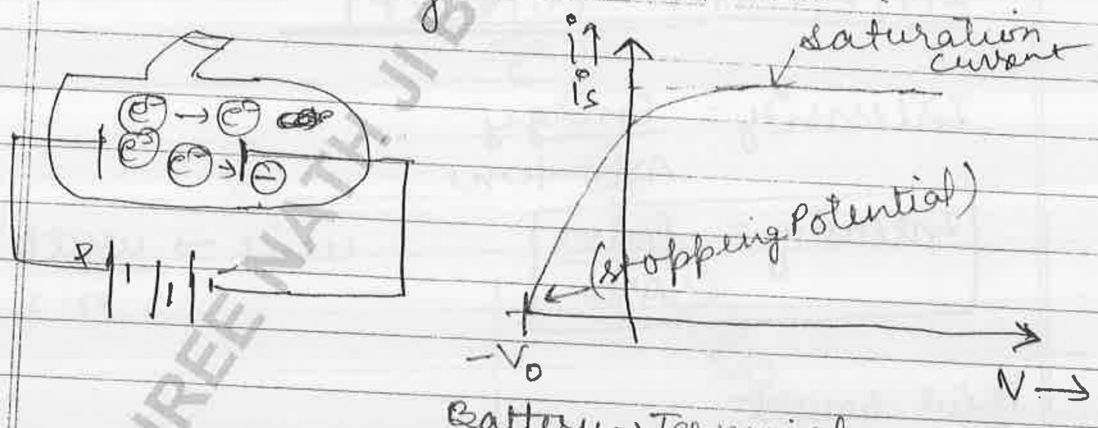



Variable Battery Voltage

Step #01 Battery zero → set

Step #02 Battery voltage ↑

Step #03 Battery Terminal Reverse

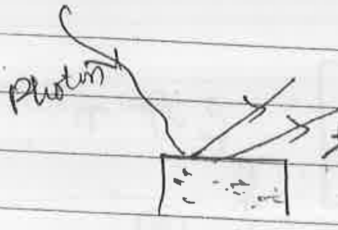



Battery → Terminal Reverse.



## concept ⇒

Distribution of K.E




* Photoelectric effect से निकलने वाले सभी $e^-$ की K.E same नहीं होती

* यह energy 0 से $K.E_{max}$ तक vary करती है।

② Momentum of photon –

$$p = \frac{E}{c}$$

③ Source → emit $\frac{N}{t} = \frac{P}{h\nu}$ or $\frac{N}{t} = \frac{P\lambda}{hc}$ P = Power of Source

④ $\phi = h\nu_0$

$\nu_0 = \frac{c}{\lambda_0}$

[ $\phi$ → work function
$\nu_0$ → Thresold frequency
$\lambda_0$ → Thresold wave-length ]

28 August
Lecture #02

# INTENSITY CONCEPT

Intensity = $\frac{\text{Energy}}{\text{Area} \cdot \text{time}}$

Intensity = $\frac{\text{Power}}{\text{Area}}$ unit → $\frac{\text{watt}}{m^2}$

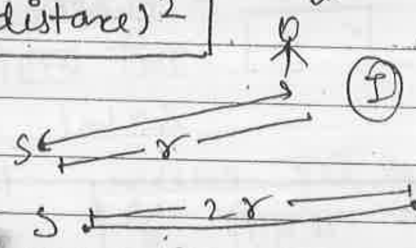
Point source

$I = \frac{\text{Power}}{\text{area}} \Rightarrow I = \frac{P}{4\pi r^2}$

$$I \propto \frac{1}{r^2} \propto \frac{1}{(\text{distance})^2}$$

दूरी ↑, Intensity ↓

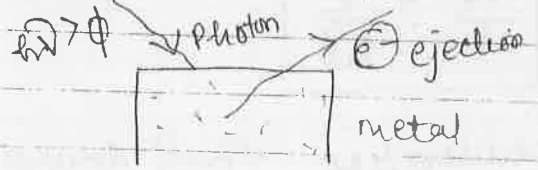
standard Note ⇒ point source




सो. (1/4) (I) [ दिमाग → दूरी → दुगुना तो I → $\frac{1}{4}$ ... I नई = ... ]

MIR

Photoelectric Effect ⇒ Emission of $e^-$ from the metallic surface when light suitable wavelength are incident on it. This phenomena is k/as Photoelectric effect.




Work function ($\phi$) → The minimum energy required to eject the electron from the metallic surface is known as work func and it is denoted by '$\phi$'.

$$\boxed{\phi = h\nu_0}$$

work function → $\phi$; $\nu_0$ → Thresold frequency

Thresold Frequency ($\nu_0$) → The minimum frequency below which photoelectric effect does not takes place is k/as thresold frequency.

$$\boxed{\nu_0 = \frac{c}{\lambda_0}}$$

$\lambda_0$ → Thresold wave-length.

Thresold wavelength ($\lambda_0$) → The maxm wavelength above which photoelectric effect does not takes place.

Lecture #01 Short Notes

① Energy of photon, $\boxed{E = h\nu = \frac{hc}{\lambda}}$

$$E = \boxed{\frac{12400 \times 10^{-10}}{\lambda}} eV$$

λ → मीटर में रखो !

Power = $\frac{\text{Energy}}{\text{time}}$ ⇒ $P = \frac{N}{t}(h\nu)$

$$\boxed{\frac{N}{t} = \frac{P}{h\nu}}$$

No. of photon/sec किसी source से निकलने वाले।

$\nu = \frac{c}{\lambda}$ ⇒ $\frac{N}{t} = \frac{P}{h\nu} = \frac{P}{h\left(\frac{c}{\lambda}\right)}$ $\boxed{\frac{N}{t} = \frac{P\lambda}{hc}}$

No. of photon/sec → $\boxed{\frac{N}{t} = \frac{P}{h\nu}}$ P → Power of source

$\boxed{\frac{N}{t} = \frac{P\lambda}{hc}}$ $\nu$ → frequency of photo

$\lambda$ → wavelength

$\frac{N}{t}$ → No. of photon/sec.

AIPMT-2007, 09, 10

Ques:- Monochromatic light of frequency $6\times10^{14}$ Hertz is produced by a laser. The power emitted by the laser is → $2\times10^{-3}$ watt then calculate the no. of photon emitted per second on an average.

1) $5\times10^{14}$
2) $5\times10^{15}$
3) $5\times10^{16}$
4) $5\times10^{7}$

Sol. $\frac{N}{t} = \frac{P}{h\nu}$ ⇒ $\frac{2\times10^{-3}}{6.6\times10^{-34}\times6\times10^{14}} = \frac{2\times10^{17}}{6.6\times6}$

$= \frac{1}{21}\times10^{17}$

$= \frac{100\times10^{15}}{21}$

$\simeq 5\times10^{15}$ Ans.

$P = nh\nu$

→ Photon does not carry any charge therefore it does not deflect in electric as well as magnetic field.

→ Photon moves with the speed of light i.e $3 \times 10^8$ m/s.

## Momentum of the Photon :-

From De-broglie hypothesis we know that–

$$\boxed{\lambda = \frac{h}{p}} \Rightarrow \boxed{p = \frac{h}{\lambda}}$$

$$\nu = \frac{c}{\lambda} \Rightarrow \lambda = \frac{c}{\nu}$$

$\lambda \rightarrow$ Put

$$p = \frac{h}{(c/\nu)} \Rightarrow p = \frac{h\nu}{c}$$

$$\boxed{p = \frac{E}{c}}$$

$p \rightarrow$ momentum

$c \rightarrow$ speed of light $3 \times 10^8$ m/s.

$E \rightarrow$ Energy

Ques: Energy of the photon is 3 MeV. Find out its momentum.

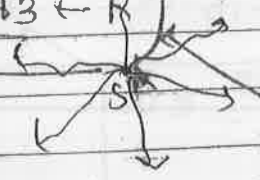
Sol: $p = \frac{E}{c} \Rightarrow p = \frac{3 \times 10^6 [1.6 \times 10^{-19}]}{3 \times 10^8}$

$p = 10^{-2} \times 1.6 \times 10^{-19}$

$= 1.6 \times 10^{-21}$ Kg·m/sec Ans

## Conceptual Point

Source → Bulb, Laser




निकलने वाले $\frac{\text{Photon}}{\text{sec}} = ?$

26 August

A.G



# • MODERN PHYSICS •

(6 Question) → AIPMT
(15 lecture)

- Photoelectric effect
- Atomic structure (Chemistry)
- → Nuclear Physics
- → Radioactivity
- → X-Ray

## Section - 'A' Photoelectric Effect

PHOTON → It is a packet of energy and the energy of each photon is given by

$E = h\nu$ → Joule

$h$ → Planck's constant

$h = 6.63 \times 10^{-34}$ J-sec.

$\nu$ → Frequency

E → Energy of each photon

$\because \nu = \frac{c}{\lambda}$

$\lambda$ → wave length

C → speed of light

Now, $E = h\nu$

$\nu$ → put

$E = \frac{hc}{\lambda}$ → Joule

(ins I U ...)

$[hc \to 2 \times 10^{-25}]$

$[1/hc = 5 \times 10^{24}]$

$1eV = 1.6 \times 10^{-19}$ Joule

$E = \frac{hc}{\lambda}$ (Joule) $\Rightarrow E = \frac{hc}{\lambda(1.6 \times 10^{-19})}$ eV

16/09

$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{\lambda(1.6 \times 10^{-19})}$ eV

$\lambda$ → हमेशा meter

$$E = \frac{12400 \times 10^{-10}}{\lambda} \text{ eV}$$

Sol:- $A = \lambda N$

$t_{1/2} = \frac{0.693}{\lambda} \Rightarrow \lambda = \frac{0.693}{t_{1/2}}$

~~$\frac{N_1}{N_2} = \frac{(t_{1/2})_2}{(t_{1/2})_1} \Rightarrow \frac{N_1}{N_2} = \frac{5}{20} = \frac{1}{4}$~~

$A = \frac{0.693}{20} \times N_1$ —(I)

$A = \frac{0.693}{5} \times N_2$ —(II)

$\frac{(I)}{(II)} \Rightarrow 1 = \frac{0.693}{20} \times \frac{5}{0.693} \times \frac{N_1}{N_2} \Rightarrow 1 = \frac{1}{4} \times \frac{N_1}{N_2}$

$\Rightarrow \frac{N_1}{N_2} = \frac{4}{1} = 4:1$

Ques. The half life of a radioactive isotope is 12.5 years. Calculate the time after which the no. of undecayed nuclei becomes $\frac{1}{32}$ of initial nuclei?

Sol. $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$

$N = \frac{N_0}{32} \Rightarrow \frac{N_0}{32 N_0} = \left(\frac{1}{2}\right)^{\frac{t}{12.5}}$

$\left(\frac{1}{2}\right)^5 = \left(\frac{1}{2}\right)^{t/12.5} \Rightarrow \frac{t}{12.5} = 5 \Rightarrow t = 62.5$ year

AIPMT 2012, 2013, 2014

Ques. The half life of a radioactive isotope 'X' is 20 yrs. & it decays into another element 'Y' which is stable. If these two elements X and Y were found to be in the ratio 1:7 in the sample of rock then find out age of the rock?

Sol:-

| | X | Y |
|---|---|---|
| माना | $N_0$ | 0 |
| बचा | N | $N_0 - N$ |

Rock $\frac{x}{y} = \frac{1}{7} \Rightarrow \frac{N}{N_0 - N} = \frac{1}{7} \Rightarrow 7N = N_0 - N$

$8N = N_0 \Rightarrow \boxed{N = \frac{N_0}{8}}$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$

$\frac{N_0/8}{N_0} = \left[\frac{1}{2}\right]^{\frac{t}{20}} \Rightarrow 3 = \frac{t}{20} \Rightarrow t = 60$ years

Ques:- The $t_{1/2}$ of a Radioactive Isotope 'X' is $4.5 \times 10^9$ years. The element 'X' decays into 'Y' which is stable. If these two are in the ratio of 1:15 in the sample of rock then find out age of the rock?

Sol:-

| | X | Y |
|---|---|---|
| माना | $N_0$ | 0 |
| बचा | N | $N_0 - N$ |

Rock $\frac{X}{Y} = \frac{1}{15} \Rightarrow \frac{N}{N_0 - N} = \frac{1}{15} \Rightarrow 15N = N_0 - N$

$16N = N_0 \Rightarrow N = \frac{N_0}{16}$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$

$\frac{N_0}{16 N_0} = \left(\frac{1}{2}\right)^{\frac{t}{4.5 \times 10^9}} \Rightarrow \left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^{\frac{t}{4.5 \times 10^9}}$

$\frac{t}{4.5 \times 10^9} = 4 \Rightarrow$

$t = 18 \times 10^9$ years.

Ques:- The $t_{1/2}$ of a radioactive element is 60 day at time $t_2 \rightarrow \frac{2}{3}$ of Initial decay मतलब $\frac{1}{3}$ बचा & time $t_1 \rightarrow \frac{1}{3}$ of Initial decay मतलब $\frac{2}{3}$ बचा. find $(t_2 - t_1)$?

Sol:- $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$

at $t = t_2 \Rightarrow \frac{N_0}{3N_0} = \left(\frac{1}{2}\right)^{\frac{t_2}{60}} \Rightarrow \frac{1}{3} = \left(\frac{1}{2}\right)^{\frac{t_2}{60}}$

at $t = t_1 = \frac{2N_0}{3N_0} = \left(\frac{1}{2}\right)^{t_1/60} = \frac{2}{3} = \left(\frac{1}{2}\right)^{\frac{t_1}{60}}$

$\frac{2}{3} = \left(\frac{1}{2}\right)^{\frac{t_2}{60} - \frac{t_1}{60}}$

$\frac{2}{3} = \left(\frac{1}{2}\right)^{\frac{t_2 - t_1}{60}}$

Sol:- $N = N_0 e^{-\lambda t} \Rightarrow t_2 \rightarrow \frac{2}{3}$ खर्च बचा $\frac{N_0}{3}$

$$\boxed{\frac{N_0}{3} = N_0 e^{-\lambda t_2}} \quad -(1)$$

$t_1 \rightarrow \frac{1}{3}$ खर्च बचा $\frac{2}{3}N_0$

$$\boxed{\frac{2N_0}{3} = N_0 e^{-\lambda t_1}} \quad -(2)$$

$\frac{N_0/3}{2N_0/3} = \frac{N_0 e^{-\lambda t_2}}{N_0 e^{-\lambda t_1}} \Rightarrow \frac{1}{2} = e^{-\lambda t_2} e^{\lambda t_1}$

$\frac{1}{2} = e^{-\lambda(t_2 - t_1)}$

$\ln\frac{1}{2} = -\lambda(t_2 - t_1) \Rightarrow 0 - \ln 2 = -\frac{\ln 2}{t_{1/2}}(t$

$\frac{0.693}{\lambda}$

$t_{1/2} = t_2 - t_1$

$= \underline{60 \text{ days}}$ उत्तर

**Ques:-** The activity of the sample is $R_1$ at time $t_1$ and activity of the sample become $R_2$ at time $t_2$ then find the ratio of $\frac{R_1}{R_2}$ ?

**Sol:**

$$A = A_0 e^{-\lambda t}$$

$$R_1 = R_0 e^{-\lambda t_1} \quad -(I)$$

$$R_2 = R_0 e^{-\lambda t_2} \quad -(II)$$

$\frac{(I)}{(II)}$ $$\frac{R_1}{R_2} = \frac{R_0 e^{-\lambda t_1}}{R_0 e^{-\lambda t_2}} \Rightarrow \frac{R_1}{R_2} = e^{-\lambda t_1 + \lambda t_2} = e^{\lambda(t_2 - t_1)}$$ Ans

**α- Decay**

$$^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He + Q$$

**β- decay**

$$\beta^- \rightarrow {}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \bar{\nu} + Q$$

$$\beta^+ \rightarrow {}^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e + \nu + Q$$

**Ques.** $^{222}_{88}Rn \longrightarrow {}^{206}_{82}Pb$ कितने α और कितने β निकले!

↑ Initial ↑ final

**Sol:** $$\text{No of } \alpha = \frac{\text{Initial A} - \text{final A}}{4} = \frac{222-206}{4} = 4\alpha$$

अगर 4α निकले तो z → 8 कम होना चाहिए था क्योंकि
(एक α से z → 2 कम होता है।)

z = 88 − 8 = 80 होना चाहिए था।

पर z = 82 है मतलब
2β⁻ है।

Que. $^{234}_{90}Th \longrightarrow ^{206}_{82}Pb$   $\alpha, \beta = ?$

Sol. $\alpha = \frac{234-206}{4} = \frac{28}{4} = 7$

7 $\alpha$ मतलब $Z \longrightarrow$ ~~234 − 2×7~~ = ~~234 − 14 = 220~~

14 कम होना ~~90 − 82 = 8~~

चाहिए i.e = 90 − 14 = 76 होना चाहिए था

पर है 82, इसका मतलब $6\beta^-$

Que. $^{180}_{70}A_1 \xrightarrow{\alpha} ^{176}_{68}A_2 \xrightarrow{\beta^-} ^{176}_{69}A_3 \xrightarrow{\alpha} ^{172}_{67}A_4 \xrightarrow{\beta^+} ^{172}_{66}A_5$

सभी के mass No. और Atomic No. = ?

Sol. For $A_2 \rightarrow \alpha = 180 - 4 \Rightarrow 176$
नीचे $\Rightarrow 70 - 2 = 68$ $A_2$

$^{176}_{69}A_3$, $^{172}_{67}A_4$, $^{172}_{66}A_5$

Probability of Survival / Probability of Decay →

Que. A Radioactive isotope have a half life of 10 years then calculate the probability of the survival of the Nuclei after 3 half life?

Sol. $N_0 \xrightarrow{t_{1/2}} \frac{N_0}{2} \xrightarrow{2t_{1/2}} \frac{N_0}{4} \xrightarrow{3t_{1/2}} \frac{N_0}{8}$

Probability of survival = $\frac{N_0/8}{N_0} = \frac{1}{8}$

$= \frac{1}{8}$ उत्तर

**Que:-** A radioactive Isotope has a half life 200 years then calculate the probability of decay after 3 half lifes?

**Sol:-** $N_0 \xrightarrow{t_{1/2}} N_0/2 \xrightarrow{2t_{1/2}} N_0/4 \xrightarrow{3t_{1/2}} \frac{N_0}{8}$ बचा

∴ क्षय (decay) $= N_0 - \frac{N_0}{8} = \frac{7N_0}{8}$

Probability of decay $= \frac{7N_0/8}{N_0} = 7/8$ उत्तर

**Radioactive Equilibrium →**

$A_1 \xrightarrow{\lambda_1} A_2 \xrightarrow{\lambda_2} A_3 \longrightarrow$ - - - - final stable product

$N_1$ $N_2$ $N_3$

Production Rate of $A_2$ = disintegration rate of $A_1$ = $\lambda_1 N_1$ ✓

Production rate of $A_3$ = disintegration rate of $A_2$ = $\lambda_2 N_2$ ✓

**$A_2$ equilibrium**

| production Rate of $A_2$ = Disintegn rate of $A_2$ |

at equilib. $\boxed{\lambda_1 N_1 = \lambda_2 N_2}$

**Que:-** In a Nuclear Reactor, a radioactive Isotope is formed at a constant rate of 1000 per sec. If the mean life of the Isotope is 40 minutes then at steady state/equilib. calculate the no. of Radioactive Nuclei?

**Sol.** $N \times \frac{1}{40 \times 60} = 1000 \Rightarrow N = 24 \times 10^5$

← $\tau_{mean}$ is $\frac{1}{\lambda}$

NOTE :→ $t_{1/2} = \frac{0.693}{\lambda} = \frac{\ln 2}{\lambda}$

$t_{mean} = \frac{1}{\lambda}$

$$\frac{t_{1/2}}{t_{mean}} = \ln 2$$

$t_{1/2}$ : $N_0 \longrightarrow N_0/2$

$t_{mean}$ : $N_0 \longrightarrow \frac{1}{e} N_0$

$A = \lambda N \Rightarrow$

$N = N_0 e^{-\lambda t}$

$A = A_0 e^{-\lambda t}$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$

$\frac{A}{A_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$

Ques:- The mean life of a radioactive element is 10 min. then calculate its half life.

Sol: $t_{1/2} = \frac{0.693}{\lambda} = t_{1/2} = \frac{\ln 2}{\lambda} \times \frac{1}{\lambda} \Rightarrow \ln 2 \times t_m$

$$t_{1/2} = \ln 2 \times 10 \text{ Ans}$$

Ques: At $t=0$, the count per minute of a radioactive sample is $N_0$. After 5 minutes its activity becomes $\left(\frac{1}{e}\right)$ of its initial Activity. Now calculate the time so that activity reduces to half to its initial value.

Sol: $\frac{1}{e} \longrightarrow t_{mean}$

$t_{1/2} = \frac{0.693}{\lambda} \; \frac{\ln 2}{\lambda} \Rightarrow \ln 2 \times \frac{1}{\lambda} = \ln 2 \times t_m$

$= 5 \times \ln 2$

A = λN द्वारा mole concept का use होता है →

Ques: $A = \lambda N$

Activity
unit → d.p.s
1 curie = 1 Ci = $3.7 \times 10^{10}$ dps

λ → decay constant
बताते हैं
$t_{1/2} = \frac{0.693}{\lambda}$ ⇒ λ = ?
tmean = $\frac{1}{\lambda}$ ⇒ λ = ?

N → No. of Nuclei left at that time

A → Activity
(disintegration rate = decay rate = count rate)

eg: 5 gm $^{238}U$ में No. of Nuclei = ? (N)

$^{238}U$ ⇒

238 gm में आने वाले atom = $N_A$

1 gm में = $\frac{N_A}{238}$

5 gm में आने वाले atoms की संख्या = $\frac{N_A \times 5}{238}$

Profile: कितनी amt (mass) No. of atoms = given

$N_A$ atoms ⟶ molar mass

1 atom ⟶ $\frac{\text{molar mass}}{N_A}$

N atom ⟶ $\frac{\text{molar mass} \cdot N}{N_A}$

Ques: Obtain the amt of $^{210}Po$ (polonium) required in order to get activity of 5 mCi and half life of it is 138 days?

Sol: हमें Polonium का mass निकालना है।

$A = \lambda N$

$A = 5\ mCi = 5 \times 3.7 \times 10^{7}$ dps

$t_{1/2} = 138$ days $= \frac{0.693}{\lambda}$ ⇒ $138 \times 24 \times 60 \times 60 = \frac{0.693}{\lambda}$

⇒ $\lambda = \frac{0.693}{138 \times 24 \times 60 \times 60}$

$A = \lambda N$

$$5 \times 3.7 \times 10^7 = \frac{0.693}{138 \times 24 \times 60 \times 60} \times N$$

$$N = \frac{5 \times 3.7 \times 138 \times 24 \times 60 \times 60 \times 10^7}{0.693}$$

No. of nuclei → 

अब → mass required →

$N_A$ atom ⟶ 210 gm

1 ⟶ $\frac{210}{N_A}$

N ⟶ $\frac{210 \times N}{N_A} \Rightarrow \frac{210 \times 5 \times 3.7 \times 138 \times 24 \times 60 \times 60 \times 10^{7}}{6.023 \times 10^{23} \times 0.693}$ gm

Ques: The half life of the Radium $^{226}Ra$ is 1620 year then calculate the No. of atoms that'll decay from its 1 gm sample per sec?

sol$^n$: $A = \lambda N$ $\qquad \lambda = \frac{0.693}{1620 \times 365 \times 24 \times 60 \times 60}$

226 gm ⟶ $N_A$

1 ⟶ $\frac{N_A}{226}$ =

$$A = \frac{0.693}{1620 \times 365 \times 24 \times 60 \times 60} \times \frac{6.023 \times 10^{23}}{226} \Rightarrow \frac{4.14 \times 10^{20}}{1620 \times 365 \times}$$

A = ~~0.0000000 $10^{17}$~~

$A = 3.61 \times 10^{10}$ dps.

→ For → $\boxed{A = \lambda N}$

(A → Activity; λ → Decay const.; N → No. of atoms)

(mole concept से निकालेंगे)

Trick ⇒ $\dfrac{\text{mass}}{\text{Molar mass}} = \dfrac{\text{No. of atoms}}{N_A}$

NCERT 13.9

**Ques:** Obtain the amt. of $^{60}Co$ necessary to provide a radioactivity of 8mCi. The half life of $^{60}Co$ is 5.3 years?

**Sol:** $A = 8\,mCi = 8\times10^{-3} \times 3.7\times10^{10}\ Ci$

$A = \lambda N$ $\quad \left[\dfrac{\text{mass}}{\text{molar mass}} = \dfrac{\text{No. of atoms}}{N_A}\right]$

$8\times3.7\times10^{7} = \dfrac{0.693}{5.3\times365\times24\times60\times60} \times \dfrac{\text{mass}}{\text{molar mass}} \cdot N_A$

$8\times10^{7}\times3.7 = \dfrac{0.693}{5.3\times365\times24\times60\times60} \times \dfrac{\text{mass}}{60} \times 6.023\times10^{23}$

$\boxed{\text{mass} = 7.1\times10^{-6}\ gm}$

13.10 NCERT

**Ques:** The half life of $^{90}Sr$ is 28 years. Calculate the disintegration rate (Activity) of $15\times10^{-3}$ gm of this isotope?

**Sol:** $A = \lambda N$

$A = \dfrac{0.693}{28\times365\times24\times60\times60} \times \dfrac{N_A \times 15\times10^{-3}}{90}$

$A = \dfrac{0.693\times6.023\times10^{23}\times10^{-3}}{28\times365\times24\times60\times60\times6}$

$$= \frac{4.17 \times 10^{20}}{5298048000}$$

Ans check करो

$$\frac{4.17}{5.29} \times 10^{12} = 0.78 \times 10^{12}$$

Ques:- $\frac{16}{25}$ fraction remain undecayed after time 't'. Calculate the fraction of the radioactive element remain undecayed after time $\frac{t}{2}$?

Sol. $N = N_0 e^{-\lambda t}$

$\frac{16 N_0}{25} = N_0 e^{-\lambda t} \Rightarrow \frac{16}{25} = e^{-\lambda t}$

Now $\Rightarrow$ $N = N_0 e^{-\lambda t/2}$

$N = N_0 e^{-\lambda t \times \frac{1}{2}} \Rightarrow N = N_0 \times \left(\frac{16}{25}\right)^{1/2}$

$N = N_0 \left(\left(\frac{4}{5}\right)^2\right)^{1/2}$

$N = \frac{4 N_0}{5}$ Ans.

Ques:- In a factory, a radioactive Nuclei is produced at a constant rate of 10 Nuclei/sec. If the decay constant of this Nuclei is $\frac{1}{2}$ sec$^{-1}$ then calculate the time when no. of Nuclei becomes 10 and initially there is no Nuclei present?

से बन रहे हैं

Sol.

$\frac{dN}{dt} = +10 - \lambda N$ ← से टूट रहे हैं।

$\frac{dN}{dt} = 10 - \frac{1}{2} N \Rightarrow \int \frac{dN}{10 - \frac{1}{2} N} = \int dt \Rightarrow \int_{N=0}^{N=10} \frac{2\,dN}{20 - N} = \int_{t=0}^{t} dt$

→

# NUCLEAR FISSION.

1932 → chadwick discovered Neutron

1939
[Otto hann, strauss-man

$${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236*}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3({}^{1}_{0}n) + Q$$

(slow moving Neutron) — 3 Neutron

ধীরে

$$\boxed{Q = 200\ MeV}$$

↓ Each Uranian nucleus की Fission से

235 U का एक atom fission होता, तब इतनी energy release होती।

$^{238}U$ — 99.3% ; $^{235}U$ — 0.7%

↑ Fissionable
(slow moving) (Thermal Neutron)

→ $${}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U \longrightarrow {}^{133}_{51}Sb + {}^{99}_{41}Nb + 4({}^{1}_{0}n)$$

another example →

$${}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{140}_{54}Xe + {}^{94}_{38}Sr + 2({}^{1}_{0}n)$$

On an average → 2.5 Neutron are produced per fission

Ques:- Calculate the energy released by the fission of 10 gm 235U and it is given that 200 MeV energy is released per fission of 235U?

Sol:- 235 gm ⟶ $N_A$ atom

10 ⟵ $\frac{N_A}{235} \times 10$ ← यही No. of Nuclei है

1 Nucleus की fission — 200 MeV

$\frac{N_A}{235} \times 10$ Nuclei — $200 \times 10 \times N_A$ ...

$= 51.06 \times 10^{22}$ MeV $N_A$

$= 8.51 \times 10^{2}$ MeV

Note → एक atom के fission होने से →

$$\left[\begin{array}{c} 200\ MeV \\ \Downarrow \\ 3.2 \times 10^{-11}\ Joule \\ \Downarrow \\ \frac{3.2 \times 10^{-11}}{3.6 \times 10^{6}}\ KWHr \end{array}\right]$$

Ques: calculate the mass required per day of $^{235}U$ in a power reactor to produce 64 Kwatt power & it is given that $3.2 \times 10^{-11}$ Joule energy is released per fission of $^{235}U$?

sol: Power = Energy/time

$$64 \times 10^3 = \frac{(3.2 \times 10^{-11}) \times N}{time} \Rightarrow \frac{N}{t} = 20 \times 10^{14}\ \text{atom or Nuclei per sec}$$

Now ⇒ $\frac{mass}{t \times molarmass} = \frac{No.\ of\ atoms\ or\ Nuclei}{N_A \times t}$

$$\frac{m}{t \times 235} = \frac{20 \times 10^{14}}{6.023 \times 10^{23}} \Rightarrow \frac{m}{t} = \frac{4700 \times 10^{14}}{6.023 \times 10^{23}}$$

$$\frac{m}{t} = 780.34 \times 10^{-9}\ gm/sec$$

1 sec —— $780.34 \times 10^{-9}$ gm/sec

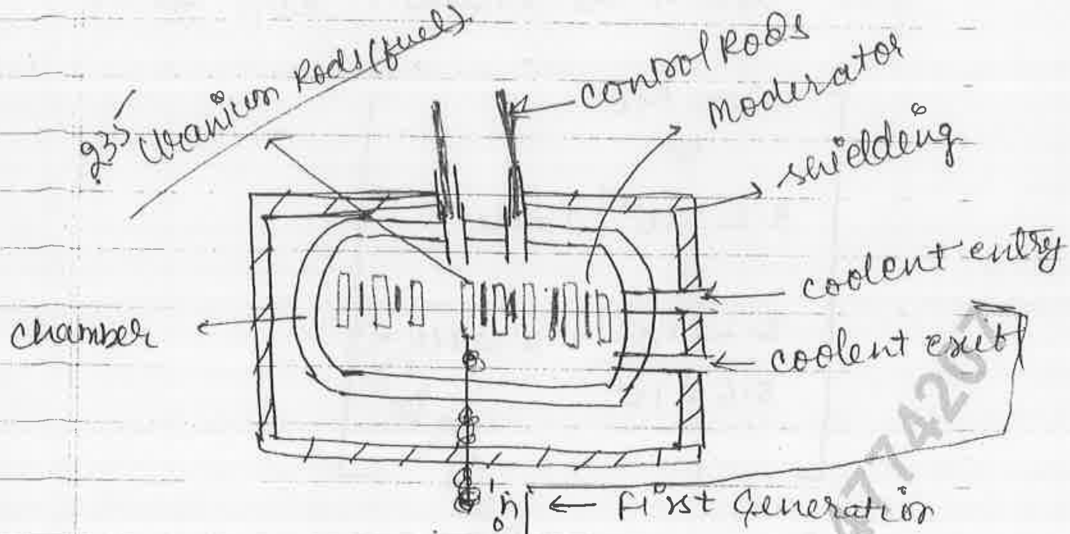
1 day —— $780.34 \times 10^{-9} \times 24 \times 60 \times 60$

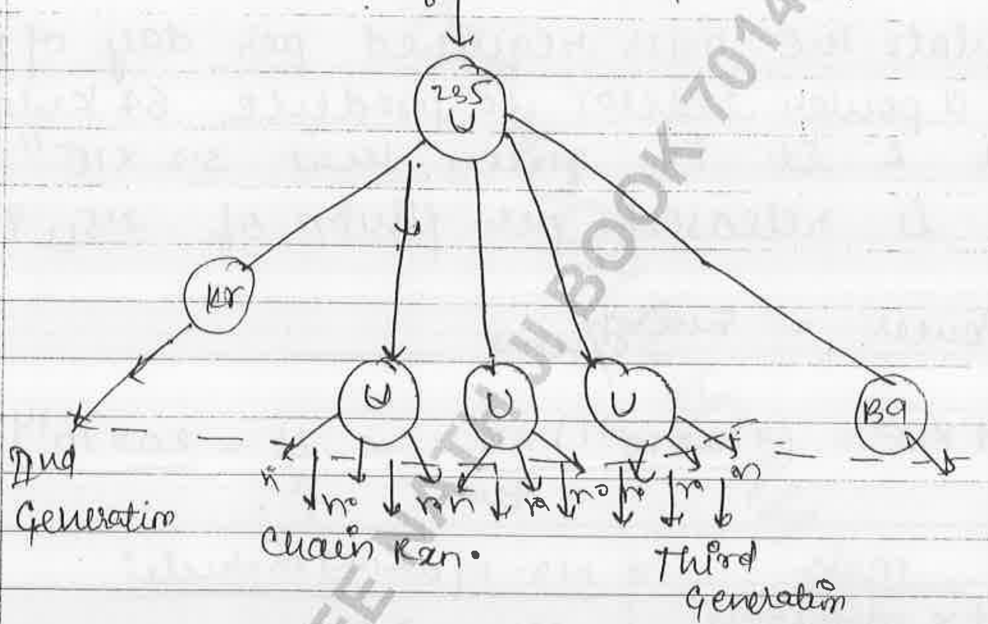
$= 67421376 \times 10^{-9}$

$= 0.067\ gm/day$ ✓ Ans.

For Boards

# NUCLEAR REACTOR




Chain Rxn. → controlled
→ Uncontrolled

$$^{1}_{0}n + ^{235}_{92}U \longrightarrow Ba + Kr + 3(^{1}_{0}n) + 200\,MeV$$

↑ slow moving Neutron (0.04 eV)

↑ तीन न्यूट्रान

for AIPMT

moderator → The function of moderator is slow down the speed of Neutrons.
example of moderator are → water, Heavy water etc

The best moderator is which slow down the Neutron but do not absorb the Neutrons

$^{235}U$ $^{238}U$
Enrich ← ↑ 0.7% ↑ 99.3%
$^{235}U$ ⇓ 3%
(Fissionable)

multiplication factor (K) = No of fission produced by neutron in Given generation / No of fission produced by Neutron in previous generation

K > 1 i.e Uncontrolled Rxn
⇓
supercritical

K = 1 i.e controlled Rxn
⇓
Critical Reactor
steady
(Nuclear Reactor)

K < 1 Chain Rxn 'll stop
⇓
subcritical

for AIPMT
Controlled Rods → The functioning of the controlled Rod is to absorb the Neutrons.
Cadmium Rods are used bcoz they are the good absorber of neutrons.

AIIMS-2013

**Ques:-** If the power of the reactor is 100 KW then calculate rate of fission ? (Given that 200 meV energy is released by the per fission of 235U).

**Sol^n** -

$$\text{Power} = \frac{\text{Energy}}{\text{time}}$$

200 MeV $= 3.2 \times 10^{-11}$ Joule

$$100 \times 10^3 = \frac{(3.2 \times 10^{-11}) N \text{ Joule}}{t}$$

$$\frac{N}{t} = \frac{100}{3.2} \times 10^{14}$$

$$= 31.25 \times 10^{14} \ \frac{\text{Nucleus}}{\text{sec}}$$

$$= 3.12 \times 10^{15} \text{ Nucleus/sec}$$

or Rate of fission **Ans.**

---- x ----

# NUCLEAR FUSION

\# Light Nuclei

⇓

Fuse

⇓

Heavy Nuclei (Relatively stable)

⇓

Energy Released

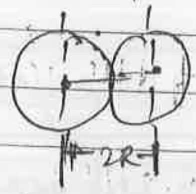
\# Coulombic Repulsion

⇓

Height of coulombic barrier →

कोई भी alee साथ नहीं रहती है

$^1_1H \cdot \ ^1_1H \cdot$ let, $R = 1 \times 10^{-15}$




$$\therefore U = \frac{Kq_1q_2}{r} \Rightarrow U = \frac{9 \times 10^9 \times 1.6 \times 10^{-19} \times 1.6 \times 10^{-19}}{2 \times 10^{-15}}$$

$\because$ P.E. $\Rightarrow U = 720$ KeV

K.E system $\geq$ P.E

avg. $K.E = \frac{3}{2}KT \approx 720\, keV$

⇓

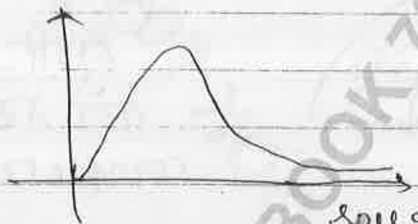
**Temp $\simeq 10^9$ kelvin**

⇓

Sun ~~ast~~ Temp.

$1.5 \times 10^7$ kelvin

See from ⇒ maxwell distribution curve
(XI class)




Conclusion :- Those molecules which have energy greater than avg. K.E. will participate in fusion

Examples

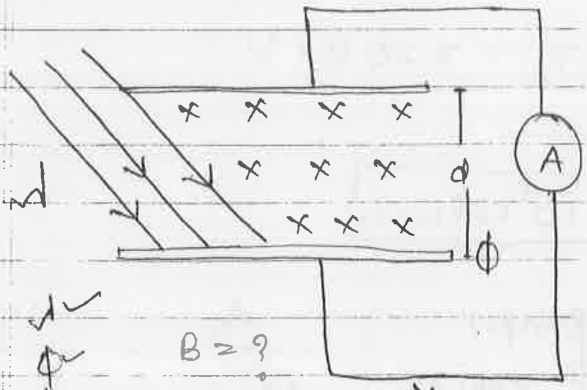
(1) $^1_1H + ^1_1H \longrightarrow ^2_1H + e + \nu + 0.42\, MeV$

(2) $^2_1H + ^2_1H \longrightarrow ^3_2He + n + 3.27\, MeV$

(3) $^2_1H + ^2_1H \longrightarrow ^3_1H + ^1_1H + 4.03\, MeV$

• PROBLEMS •

Q. 1.

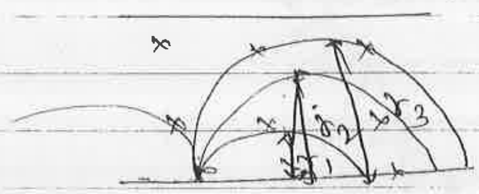



λ ✓
ϕ ✓
d ✓

B = ?

Ammeter में Reading = 0

Sol:




r < d तभी तो (A) में reading zero होगी। अगर e⁻ वहाँ तक गया तो circuit complete हो जाएगा।

$$\frac{\sqrt{2m(K.E)_{max}}}{qB} < d$$

B = ?

Einstein

$$\frac{hc}{\lambda} = \phi + K.E_{max}$$

Que. A capacitor having capacitance 'C' is discharged through Resistance 'R'. A radioactive sample decays with avg. life 'τ'. Calculate the value of 'R' so that the ratio of energy stored in the capacitor to the activity of the sample does not depend on time –

1) ✓ $R = \frac{2\tau}{C}$ 2) $R = \frac{C}{2\tau}$ 3) $R = \frac{2C}{\tau}$ 4) $R = \frac{C}{\tau}$

Sol:- capacitor = discharge

$$q = Qe^{-t/RC}$$

Ratio = $\dfrac{\text{energy stored}}{\text{activity}}$

$$\text{ratio} = \frac{q^2/2C}{A_0e^{-\lambda t}} \Rightarrow \frac{\frac{1}{2C}\left[Qe^{-t/RC}\right]^2}{A_0e^{-\lambda t}}$$

$$\text{Ratio} = \frac{1\,Q^2e^{-2t/RC}}{2CA_0e^{-\lambda t}} = \frac{Q^2}{2CA_0}e^{-\frac{2t}{RC}}e^{+\lambda t}$$

$$= \frac{Q^2e^{-2t/RC+\lambda t}}{2CA_0}$$

Question मे लिखा है Independent of time!

$$\Rightarrow -\frac{2t}{RC} + \lambda t = 0$$

$$\frac{2t}{RC} = \lambda t \Rightarrow \frac{2}{RC} = \frac{1}{\tau} \qquad \left(\because \lambda = \frac{1}{t_{mean}}\right)$$

$$R = \frac{2\tau}{C} \quad \text{Ans}$$

Ques:-

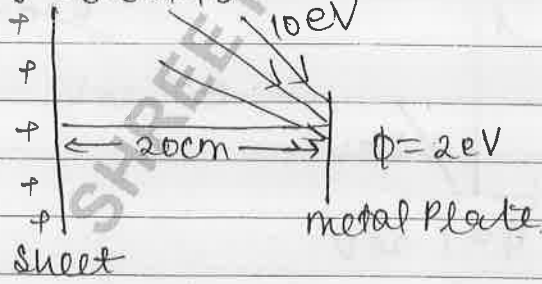
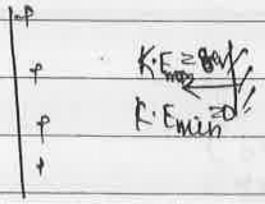



Plate पर पहुंचते समय K.E. electron की
$K.E_{min} = ?$
$K.E_{max} = ?$

Sol:-




by P.E.E. यहां पर Electron निकलेंगे –

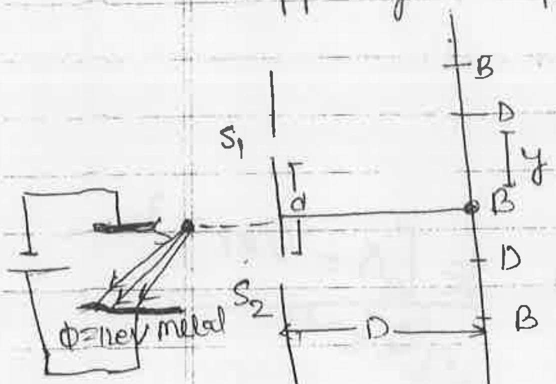
$$E = \frac{\sigma}{2\epsilon_0} = \frac{8.85\times10^{-9}}{2(8.85\times10^{-12})}$$

$E = 500 N/C$

Now ⇒ $V = Ed \Rightarrow 500\left[\frac{20}{100}\right] = 100$ volt

$K.E_{min} = 0 + 100 = 100eV$

Ques:- In the following, find out the stopping potential →




$y = 310\ nm$
$d = 1m.$
$D = 1m.$
$\phi = 1.2eV$

Sol:- $\left(B = \frac{\lambda D}{d}\right)$ wave optics

Now, $y = \frac{\lambda D}{2d} \Rightarrow 310 \times 10^{-9} = \frac{\lambda \times 1}{2 \times 1}$

$\lambda = 620 \times 10^{-9} m$

यही λ तो metal के लिए भी होगा since source तो same है।

आने वाली energy →

$E = \frac{12400 \times 10^{-10}}{\lambda} eV \Rightarrow E = \frac{12400 \times 10^{-10}}{620 \times 10^{-9}}$

$E = 2eV$

2eV

$\phi = 1.2eV$

$K.E_{max} = 0.8eV$

⇓

यही तो stopping ($V_0$) Potential है।

i.e = 0.8 Volt Ans

Que: The Initial activity of a sample at $t=0$ is $R_0$ then calculate the activity of the sample at $t = \frac{\ln 2}{\lambda} + \frac{1}{\lambda}$

(a) $\frac{R_0}{e}$ ✓(b) $\frac{R_0}{2e}$ c) $R_0 e^{-\frac{\ln 2}{\lambda}}$ d) $\frac{R_0}{\left(\frac{\ln 2}{\lambda} + \frac{1}{2}\right)}$

sol $A = A_0 e^{-\lambda t}$ at $t=0$

$A = A_0$

~~$A = A_0 e^{-\lambda\left(\frac{\ln 2}{\lambda} + \frac{1}{\lambda}\right)}$~~

~~$\ln A = \left(\frac{\ln 2}{\lambda} + \frac{1}{\lambda}\right) A_0 \times -\lambda$~~

~~$\ln A = (\ln 2 + 1) A_0$~~

~~$\ln A$~~

$A = A_0 e^{-\lambda t}$

$A = R_0 e^{-\lambda\left[\frac{\ln 2}{\lambda} + \frac{1}{\lambda}\right]}$

$A = R_0 e^{-\left[\frac{\lambda \ln 2}{\lambda} + \frac{\lambda}{\lambda}\right]}$

$A = R_0 e^{-[\ln 2 + 1]}$

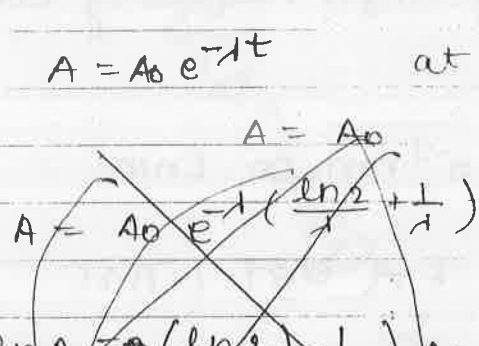
$A = R_0 e^{-\ln 2} e^{-1}$

$A = R_0 e^{\ln(1/2)} e^{-1}$

$A = R_0 (1/2)(1/e)$

$A = \frac{R_0}{2e}$ Ans

Ques:




Ionised Ion $\lambda = ?$ ejected $e^-$ may go in a circle around Ionised Ion?

sol $\frac{mv^2}{d} = \frac{K \cdot e \cdot e}{d^2}$ ← $\frac{kq_1q_2}{r^2}$

$\frac{1}{2} mv^2 = \frac{1}{2} \frac{ke^2}{d}$

$K.E. = \frac{Ke^2}{d} = \frac{\frac{1}{4\pi\epsilon_0} e^2}{2d} = \frac{e^2}{8\pi\epsilon_0 d}$

Now ⇒ $\frac{hc}{\lambda} = \phi + K.E._{max}$

$\frac{hc}{\lambda} = \phi + \frac{e^2}{8\pi\epsilon_0 d}$

(1)

MIRAJ

# X-RAY

1895 → Roentgen

⇓

1901 ( First Nobel Prize in Physics )

→ They are basically high frequency electromagnetic waves.

→ wavelength → $10^{-3}$ nm to 1 nm

$$E = \frac{hc}{\lambda}$$

E → बहुत ज़्यादा

→ speed of Ray = $3 \times 10^8$ m/s

⇓

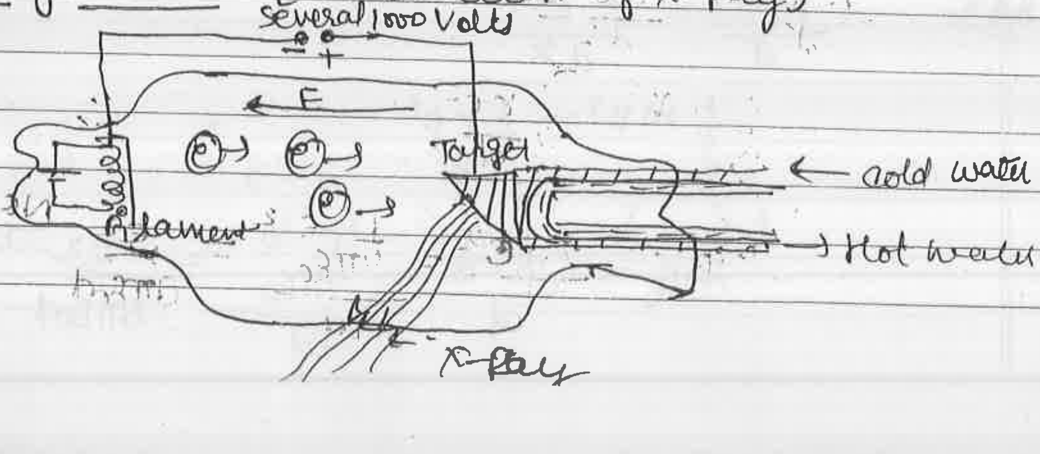
Not deflected in electric field or magnetic field.

Just behave like photon →

$E = h\nu$, $E = \frac{hc}{\lambda}$, $E = \frac{12400 \times 10^{-10}}{\lambda}$

momentum → $P = \frac{E}{C}$ (OR) $P = \frac{h}{\lambda}$

Collidge Tube [ Production of X-Ray ] -

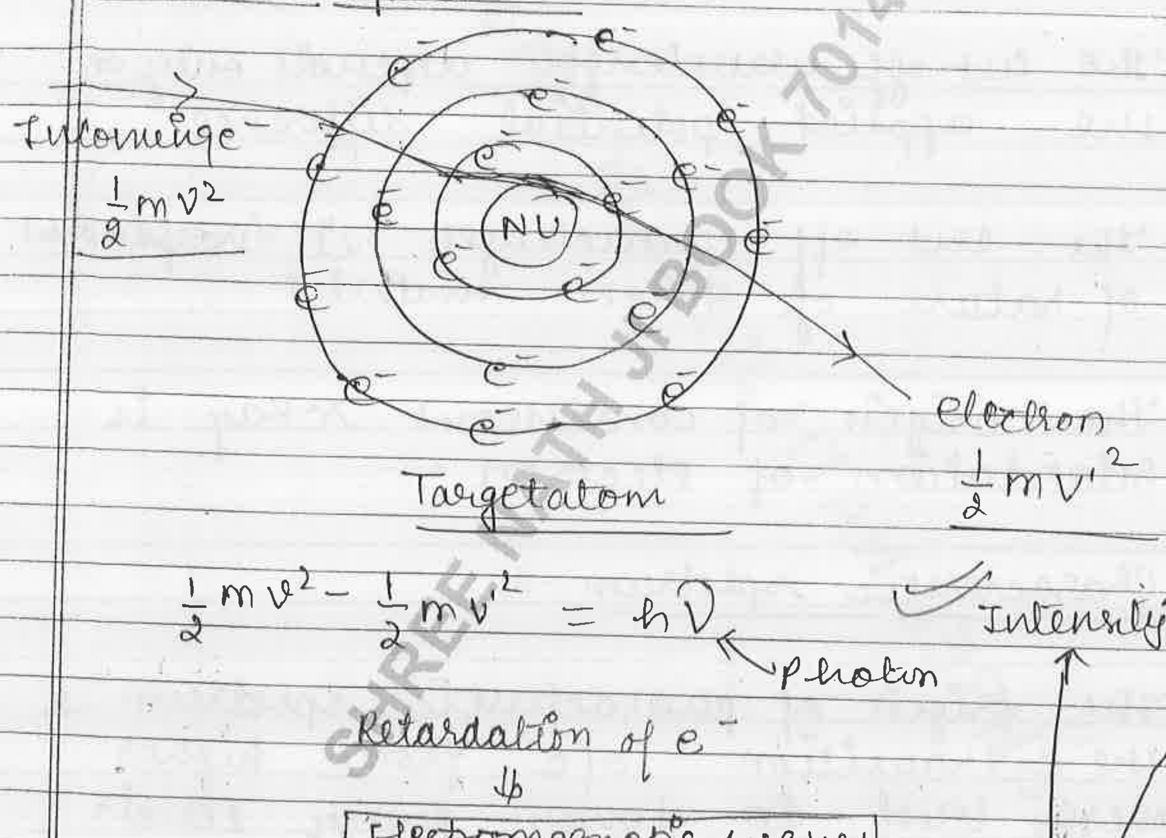


→ when highly energetic electron strike the target atom, electromagnetic radiations comes out and they are k/as X-rays

Types of spectrum

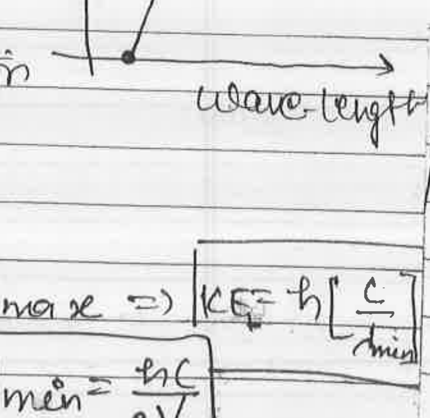
(i) Contineous spectrum →
(ii) characterstic spectrum →

Contineous spectrum →




$$\frac{1}{2}mv^2 - \frac{1}{2}mv'^2 = h\nu \leftarrow \text{photon}$$

Retardation of $e^-$
⇓
Electromagnetic waves
Brainstrahlung radiation (German)
⇓
(Breaking Radiation)




For max^m energy →

$$\frac{1}{2}mv^2 - 0 = h\nu_{max} \Rightarrow KE = h\left[\frac{c}{\lambda_{min}}\right]$$

$$eV = \frac{hc}{\lambda_{min}} \quad \boxed{\lambda_{min} = \frac{hc}{eV}}$$

(3) number, high melting pt. Generally, W & Mo is preferred for making target atom in Bulge tube.

$$\lambda_{min} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19} \times V}$$

$$\boxed{\lambda_{min} = \frac{12400}{V} A^\circ}$$

$\lambda_{min}$ → cut-off wavelength
or
Thresold wavelength

V → applied Potential diff.

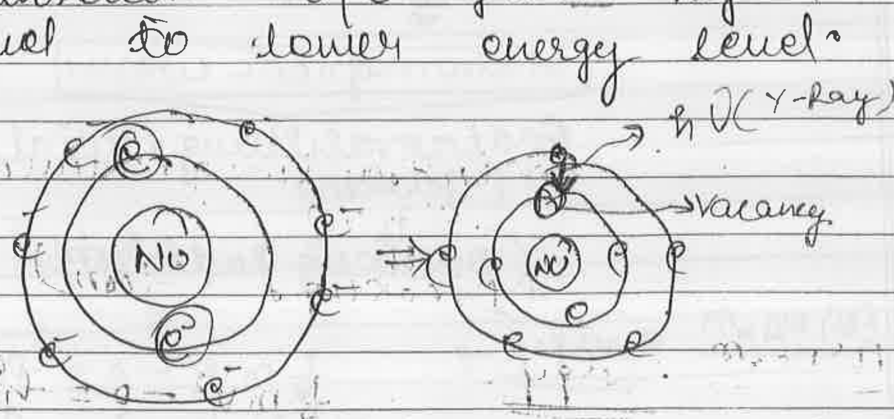
Note → The cut-off wavelength depends only on the applied potential difference.

→ The cut off wavelength is independent of nature of target material.

→ The origin of continuous X-Ray is retardation of electron.

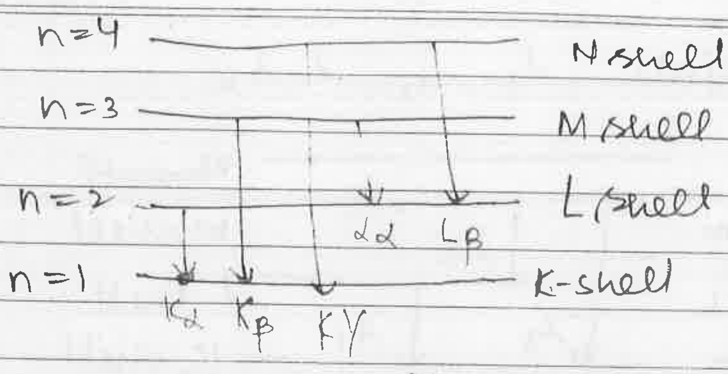
Characterstic spectrum →

The origin of characterstic spectrum is the transition of $e^-$ from higher energy level to lower energy level.




Target atom
(Generally Tungeston or Molybednum)

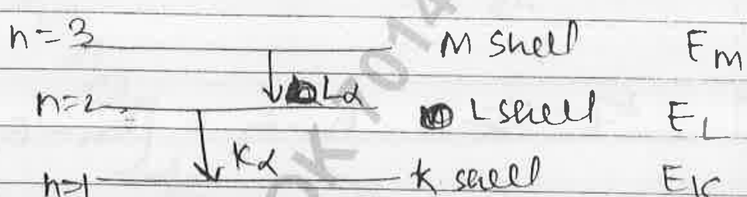
#




$K_\alpha \Rightarrow$ L shell से K-shell $\Rightarrow n = 2$ से $n = 1$

$K_\beta \Rightarrow n = 3$ से $n = 1$

eg.




$$E_L - E_K = \frac{hc}{\lambda_{K\alpha}}$$

$$E_M - E_L = \frac{hc}{\lambda_{L\alpha}}$$

$$\therefore \frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$R = 1.097 \times 10^7 \, m^{-1}$

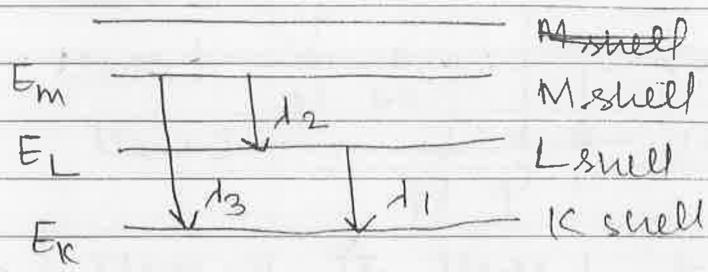
Rydberg

$$\frac{1}{\lambda} = R(Z-b)^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$b \rightarrow$ Const

$K_\alpha$ के लिए $b = 1$ बाकी Transition के लिए Given होगी।

Ques:-① Relate $\lambda_3$, $\lambda_1$, & $\lambda_2$




1) $\lambda_3 = \lambda_1 + \lambda_2$

2) $\frac{1}{\lambda_3} = \lambda_1 + \lambda_2$

3) $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$ ✓

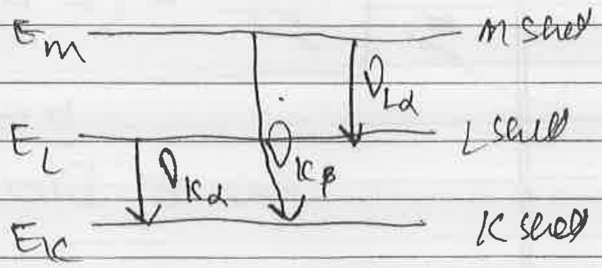
4) ~~पता नहीं~~

Sol → ~~$E_L - E_K$~~ = $E_M - E_K = [E_m - E_L] + [E_L - E_K]$

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_2} + \frac{hc}{\lambda_1}$$

$$\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$$

Ques.② Relate $\nu_{K\alpha}$, $\nu_{K\beta}$, $\nu_{L\alpha}$




1) ✓ $\nu_{K\beta} = \nu_{K\alpha} + \nu_{L\alpha}$

2) $\nu_{K\beta} = \frac{\nu_{K\alpha}}{\nu_{L\alpha}}$

3) $\frac{1}{\nu_{K\beta}} = \frac{1}{\nu_{K\alpha}} + \frac{1}{\nu_{L\alpha}}$

4) ~~पता नहीं~~

Sol: $E_M - E_K = [E_m - E_L] + [E_L - E_K]$

$$h\nu_{K\beta} = h\nu_{L\alpha} + h\nu_{K\alpha}$$

$$\boxed{\nu_{K\beta} = \nu_{L\alpha} + \nu_{K\alpha}}$$

(6)

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PREMIUM

Que: The wavelength for $K_\alpha$ line having atomic no. 57 is $\alpha$ then calculate the wavelength of $K_\alpha$ line for a atomic no. 29 ?

Ans: $K_\alpha$ संक्रमण $n>2$ से $n=1$

$b=1$

$$\frac{1}{\alpha} = R(57-1)^2\left[\frac{1}{1}-\frac{1}{4}\right]$$

$$\frac{1}{\lambda_2} = R(29-1)^2\left[\frac{1}{1}-\frac{1}{4}\right]$$

$$\frac{\frac{1}{\alpha}}{\frac{1}{\lambda_2}} = \frac{(2)^2 \times \frac{3}{4}}{\frac{3}{4}}$$

$$\lambda_2 = 4\alpha \quad \text{Ans.}$$

<u>Moseley's law →</u>

As we know that from the modified Redberg formula →

$$\frac{1}{\lambda} = R(z-b)^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$$

$$\frac{c}{\lambda} = Rc(z-b)^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$$

$$\nu = Rc(z-b)^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$$

For a particular transition →

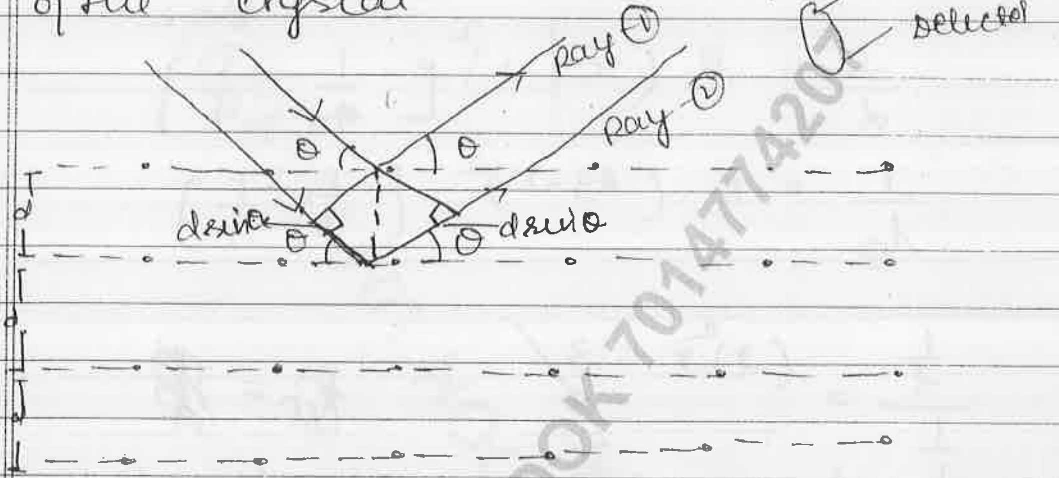
$$\nu \propto (z-b)^2$$

$$\boxed{\sqrt{\nu} \propto (z-b)}$$

MIRAJ

## BRAGG'S EQUATION :-

For the study of crystal structure, generally X-Ray are used becoz wavelength of X-Ray is the order of inter atomic separⁿ of the crystal.




M.J. Sir! $\Delta x = n\lambda$

↓ Path difference  $n = 1, 2, 3, 4$ ---

⇓

$$2d\sin\theta = n\lambda$$ [Bragg's Eqⁿ]

# A&R

$$\lambda = \frac{2d\sin\theta}{n}$$

$$\lambda_{max} = \frac{2d(1)}{(1)}$$

$$\lambda_{max} = 2d$$

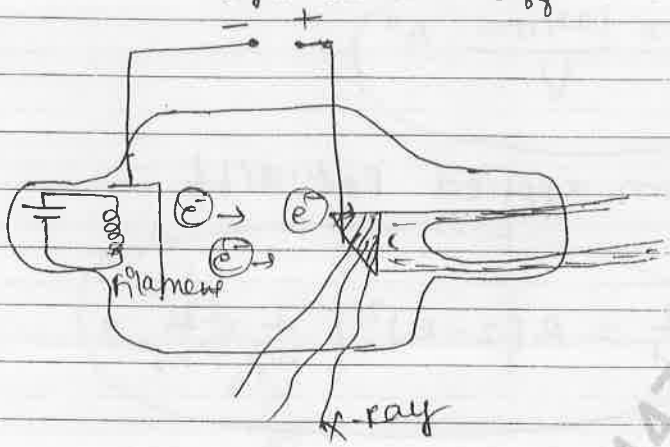
$\lambda > 2d$

⇓

~~Bragg's eqⁿ~~

(8)

CONCEPTUAL QUESTIONS:-




(1) If Filament current ↑

⇓

No. of ejected e⁻/sec ↑

⇓

No. of photon/sec ↑

⇓

Intensity ↑

Intensity control by Filament current

(2) applied potential diff ↑

K.E = qV

K.E of e⁻ ↑

⇓

More energetic photon'll be emitted

⇓

Penetration Power ↑

Penetration Power is controlled by applied pot. differ

(3) Soft x-ray → Penetration Power → low, $E = \frac{hc}{\lambda}$ (low) λ → ज़्यादा

Hard x-ray → Penetration Power → High    eg: 0.4A°, 10A

$E = \frac{hc}{\lambda}$ ... λ → कम

(P)

(1) Contineous

$$\lambda_{min} = \frac{12400}{V} A^0$$

depends on applied Pot. diff

Characteristic

$$\frac{1}{\lambda} = R(z-b)^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

'λ' depends on nature of target

Que. X-Ray tube is operated at 20 KV voltage then which of the following wavelength is not present in the contineous spectrum of X-Ray →

(1) 14 pm
(2) 28 pm
(3) 65 pm
(4) 72 pm

sol. $\lambda_{min} = \frac{12400 \times 10^{-10}}{20 \times 1000}$

$= 62 \times 10^{-12}$

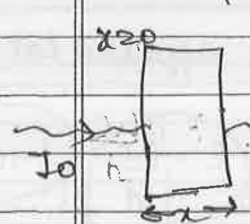
$\lambda_{min} = 62 pm$

↓

इससे छोटी wavelength possible नहीं है।

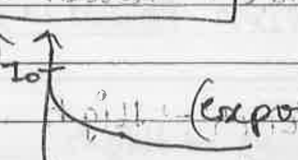
pm = Picometer = $10^{-12}$ m.

Absorption of X-Ray :-




$$I = I_0 e^{-\mu x}$$

μ → absorption coefficent
x → thickness
$I_0$ → Intensity at x=0




(exponential decay). μ → $cm^{-1}$, $mm^{-1}$, $m^{-1}$

exponential (b) power ...

2.303×3
6.909

(10)

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MIRAJ PREMIUM

**Ques:** The Intensity of the x-Ray reduces to $\frac{1}{4}$th of its Initial value when passes through a metallic sheet of 3.5 mm then calculate the absorption coefficient?

**Sol:**

$$I = I_0 e^{-\mu x}$$

$$\frac{I_0}{4} = I_0 e^{-\mu \times 3.5}$$

$$\frac{1}{4} = e^{-\mu \times 3.5}$$

$$0 - \ln 4 = -\mu \times 3.5$$

$$-\ln 2^2 = -\mu x$$

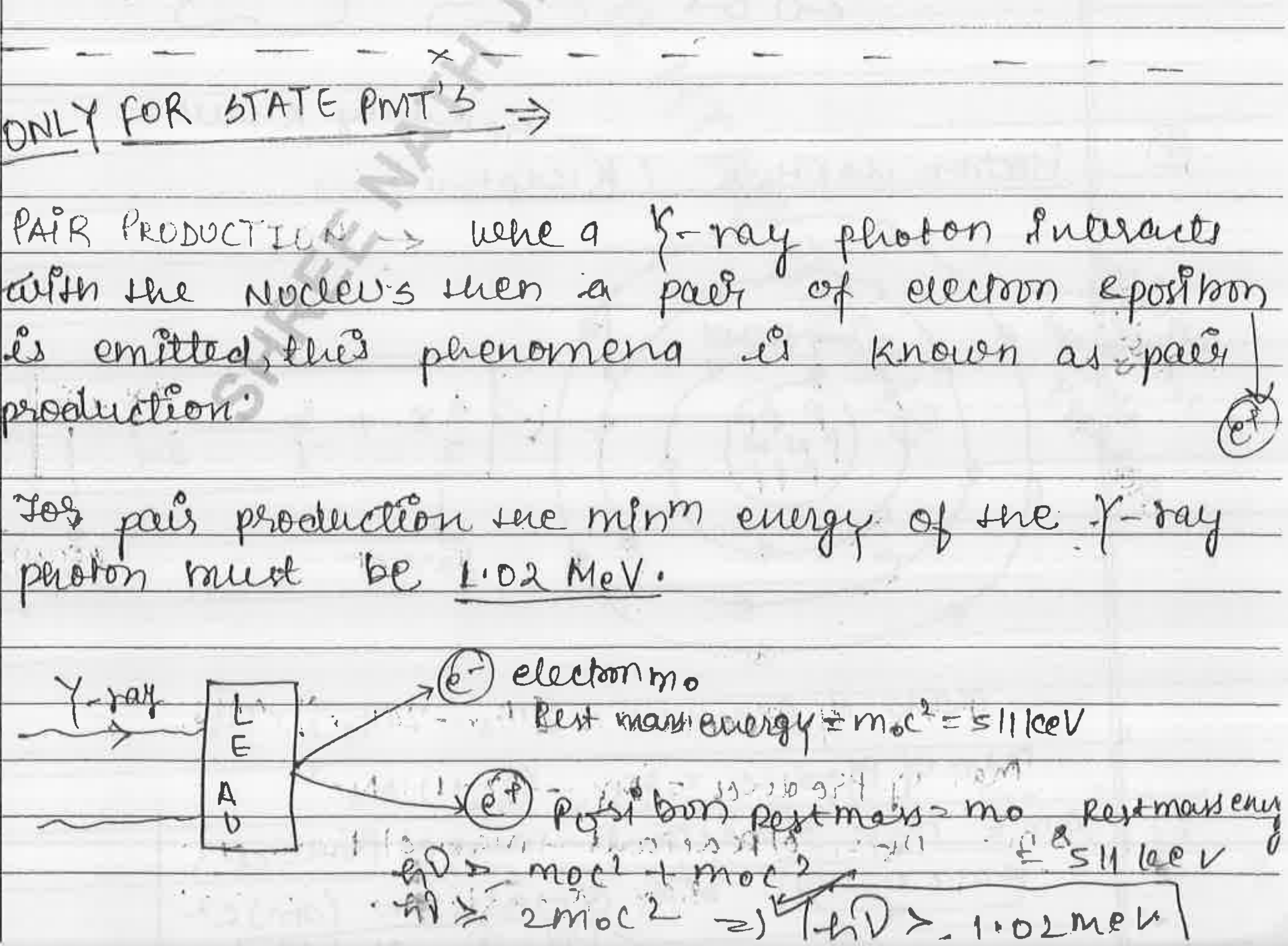
$$2\ln 2 = \mu(3.5) \Rightarrow \boxed{\mu = 0.396\, mm^{-1}}$$

---

ONLY FOR STATE PMT'S →

① PAIR PRODUCTION → when a γ-ray photon Interacts with the Nucleus then a pair of electron & positron is emitted, this phenomena is known as pair production. (Anderson)

→ For pair production the min^m energy of the γ-ray photon must be 1.02 MeV.




$$h\nu \geq m_0c^2 + m_0c^2$$

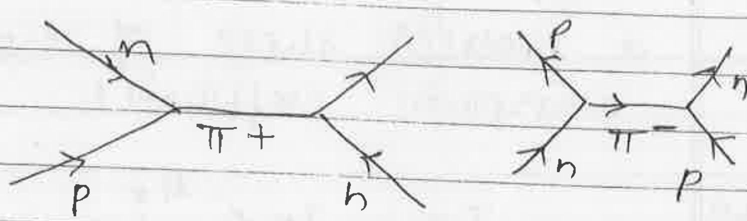
$$h\nu \geq 2m_0c^2 \Rightarrow \boxed{h\nu \geq 1.02\, MeV}$$

(11)

② Nuclear Force can be explained by 'Meson exchange theory' given by scientist Yukawa.

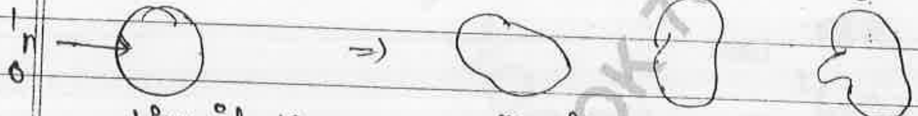
$p \rightleftharpoons n + \pi^+$

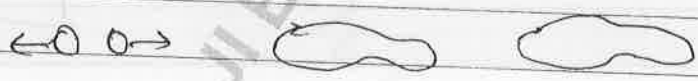
$n \rightleftharpoons p + \pi^-$



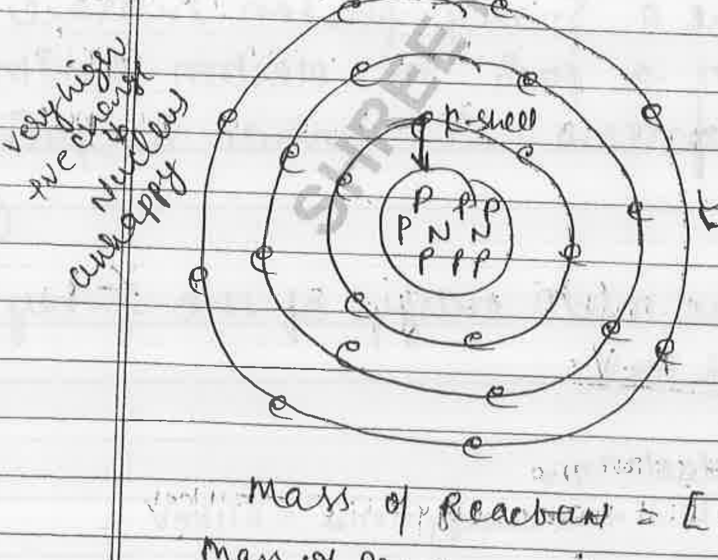

③ Nuclear Fission can be explained by 'Liquid drop model'.
(Bohr & Jhon wheeler)

$^{235}_{92}U + ^{1}_{0}n \longrightarrow {}^{236}U^* \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3(^{1}_{0}n) + 200 MeV$



④ Electron capture (K capture) → ← captured by K shell




$^{A}_{Z}X + ^{0}_{-1}e \longrightarrow ^{A}_{Z-1}Y + \nu$

Parent — Neutrino

Mass of Reactant = $[M_X - ZM_e] + M_e$

Mass of Product = $M_Y - (Z-1) M_e$

$\Delta m$ = Mass of Reactant − Mass of Product.

$\boxed{\Delta m = M_X - M_Y}$

So Q-value = $(\Delta m) c^2$

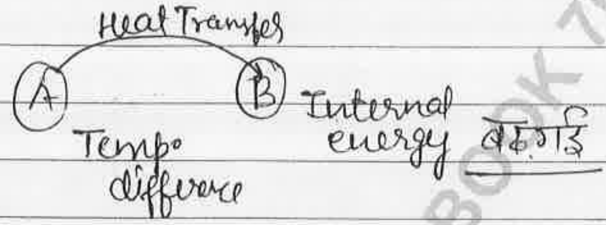
$Q = (M_X - M_Y) c^2$

1/10/2015

# THERMODYANAMICS.

→ Calorimetry
→ Thermal expansion
→ K.T.G.
→ Heat Transfer
→ Thermodyanamics

## HEAT TRANSFER.

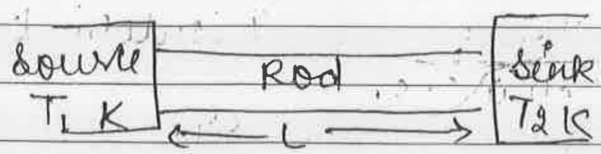



Heat ~~Transfer~~ MISNOMER

→ Energy is transit due to temperature difference.

Mode of Heat Transfer :-

① Conduction → It is a mode of Heat transfer in which energy is transferred from one point to another point by physical medium




Steady state → In steady state – i) the rate of Heat transfer from entire cross section of the rod is same.

ii) No part of heat is absorbed by the any part of rod.

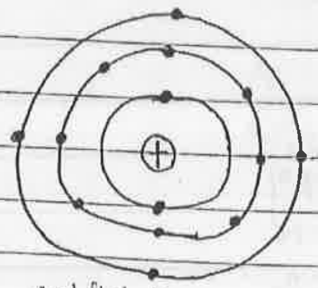
30/01/18

## Semiconductor

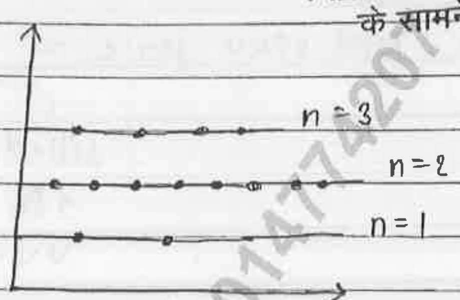
① Energy band in solid →



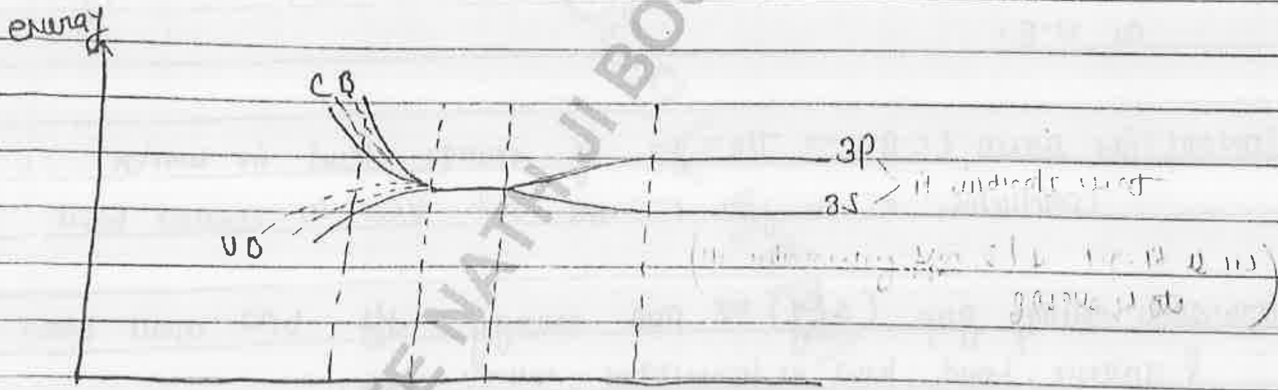
Si atom = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$



orbital diagram




Energy level diag.




dist b/w atoms.

⇒ in isolated atom, e's are int in well define energy levels. but in solid, atoms are very close to each other, so Here orbit intermix with each other & energy of e's in orbit are slightly change. when we draw energy diag for solid then we obtain gp of energy level, k/a as energy band.

may be p

↳ Energy band band or Pauli exclusion principle
↳ no of energy level in a band depend on no of interacting atom

↳ energy band are discrete & discontinuous.

⇒ IN 1 si atom, total space for $e^-$s = 8 $\begin{pmatrix} 3s \rightarrow 2 \\ 3p \rightarrow 6 \end{pmatrix}$
($3s^2$ $3p^2$)

8 → filled 4, empty 4

⇒ IN N si atom, total space for $e^-$s = 8 N

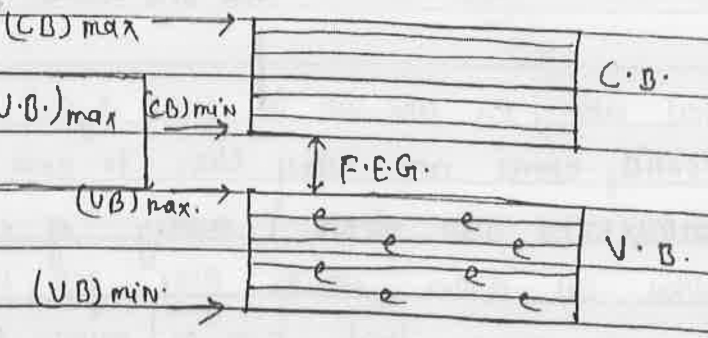
8 N → filled 4N (V.B.), empty 4N (C.B.)

(1) Valence band (V.B.) → THE gp of energy levels in WHICH valence $e^-$ or loosly bonded $e^-$ are int is K/ω as V.B.

(2) CONDUCTION BAND (C.B.) → THE gp of energy level in WHICH conduction $e^-$ or free $e^-$ are int K/ω as conduct band.

(3) Forbidden energy gap ($\Delta E_g$) ⇒ min energy diff b/ω cond band & valence band, K/ω as forbidden energy gap.
in which e are not fill

$$F.E.G = (C.B.)_{min} - (V.B.)_{max}$$




OR

required min energy to seprate loosly bonded $e^-$ from nucleus K/ω as $\Delta E_g$.

imp point → ① FEG ↑ → Means, attraction of nuclei on outer most $e^-$ ↑ (large)

(II) FEG depend on − ~~Nature~~ size of atom or Nature of solid.

↳ size of atom ↑ → FEG ↓

AIPMT

(III)

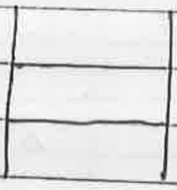
| | | | |
|---|---|---|---|
| C<br>Si<br>Ge<br>Sn<br>Pb ↓ | size ↑ | attraction ↓ of nuclei on outermost $e^-$ ↓ | FEG ↓ |

$(\Delta E_g)_C > (\Delta E_g)_{Si} > (\Delta E_g)_{Ge}$

(IV) Temp ↑se → FEG slightly ↓se (bcoz due to thermal expansion distance b/w atom ↑se)

Classification of solid acc. to FORBIDDEN ENERGY GAP →

[1] CONDUCTOR → $\alpha = +ve$




$\alpha = ?$

Conductivity $(\sigma) = 10^2$ to $10^8$ $(\Omega m)^{-1}$ (very High)

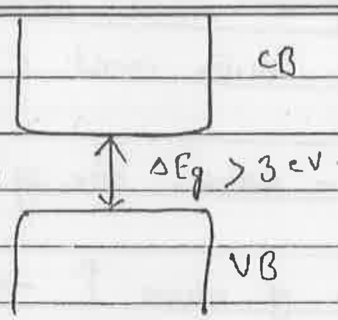
Resistivity $(\rho) = \rho = \frac{1}{\sigma} = 10^{-2}$ to $10^{-8}$ $(\Omega m)$ (very low)

Temp. coff. of ~~resist~~ Resistance.

$\alpha = +ve$

Temp ↑ (R ↑ ρ ↑) then σ ↓

[2] Insulator →



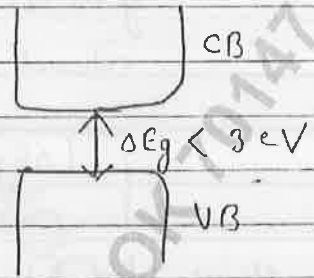

$\sigma < 10^{-9}\ (\Omega m)^{-1}$ (very low)

$\rho > 10^{9}\ \Omega m$ (very High)

$\sigma \simeq 0$

For Diamond $\Delta E_g = 6\ eV$

[3] Semiconductor →




$\sigma = 10^{-5}$ to $10^{6}\ (\Omega m)^{-1}$

$\rho = 10^{5}$ to $10^{-6}\ \Omega m$

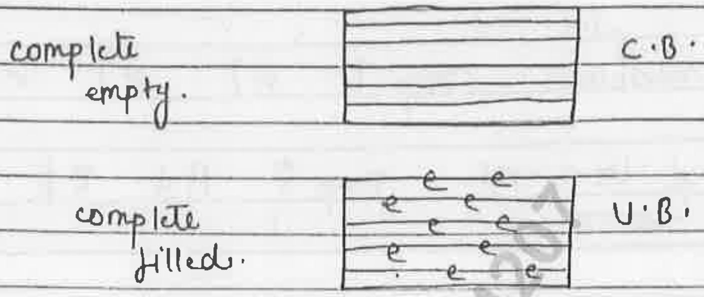
For Si $\Delta E_g = 1.12\ eV$

Ge $\Delta E_g = 0.7\ eV$

Ge $\Delta E_g = 0.67$ (room temp) $\Delta E_g = 0.7\ eV$

GeAs $\Delta E_g = 1.5\ eV$

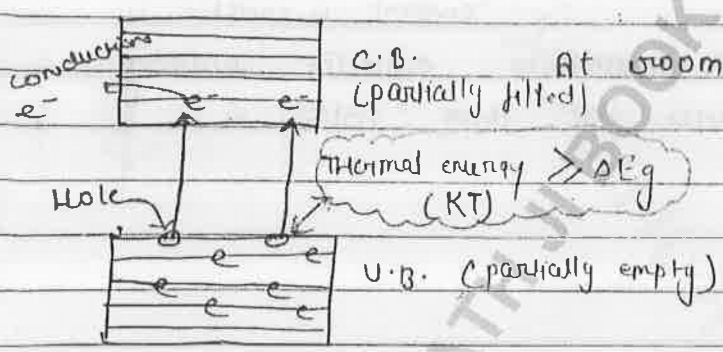
## Effect of Temp on S.C. ⇒




at 0 K Temp

thermal energy $= \frac{3}{2}KT \simeq KT = 0$

at 0 K Temp → behave a perfect insulator




At room Temp (300 K) → behave a conductor

important

** current $I = neAv_d$

$v_d = \mu E = \frac{eE}{m}\tau$

$\alpha = ?$

$\alpha = -ve$  $\sigma = ne\mu$ , $\rho = \frac{1}{\sigma}$  n (no of charge carrier)

Dominant

(in S.C.) ⇒ Temp ↑  $n$ ↑↑  $v_d$ ↓ ⇒ I ↑  R ↓

($\Delta E_g \leq 3$ eV) (Temp ↑) → (R ↓  $\rho$ ↓) ($\sigma$ ↑)

so, $\alpha = -ve$

↳ n ↑ , I ↑

(2) in conductor ( $\Delta E_g = 0$ )
Temp ↑ n ↑ τ ↓ ($V_d$ ↓↓) dominant

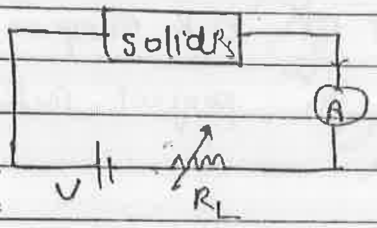
| Temp ↑, $V_d$ ↓ I ↓, R ↑, ρ ↑, σ ↓
($\alpha$ = +ve)

Q- if Al & Si are Heated then their conductivity — ?

Al → conductor ($\alpha$ = +ve) Temp ↑ R ↑ ρ ↑ σ ↓

Si → S.C. ($\alpha$ = −ve) Temp ↑ R ↓ ρ ↓ σ ↑

Que →




$R_S$ → resist of solid
Here $R_S$ & $R_L$ in series so current is const.

if Temp. of solid ↓se & to maintain ammeter reading constant value of $R_L$ resistance ↓se then solid is

I = const
$R_{net}$ = const

$R_S + R_L$ = const
if $R_L$ ↓se $R_S$ ↑

Temp ↓ $R_S$ ↑

so solid is S.C.

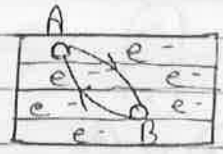
**Concept of Hole** → When V.e⁻ move from V.B to C.B. then a vacancy of $e^-$ produce in V.B k/w as Hole.

Due to random motion, Hole consider as charge carrier in S.C.

**Properties of Hole** →

- Hole is a imaginary charge carrier.
- Hole always tht in V.B.
- Charge on Hole assume to be equal to charge on $e^-$ but (+)ve.
- Motion of Hole related to motion of V $e^-$ or loosly bonded $e^-$.

- if Hole move A to B, it means a bonded $e^-$ (valence) $e^-$ move from B to A.




important

- Mobility of Hole is less than mobility of $e^-$ bcoz Hole (V$e^-$) have less energy compared to conduction $e^-$.
($\mu$)

$$ma = F = qE$$

$$m = \frac{F}{a} \quad \frac{qE}{\mu \to \text{mobility}}$$

mass ↑, mobility ↓

- effective mass of Hole is greater than mass of $e^-$ bcoz $\{\mu_h < \mu_e\}$

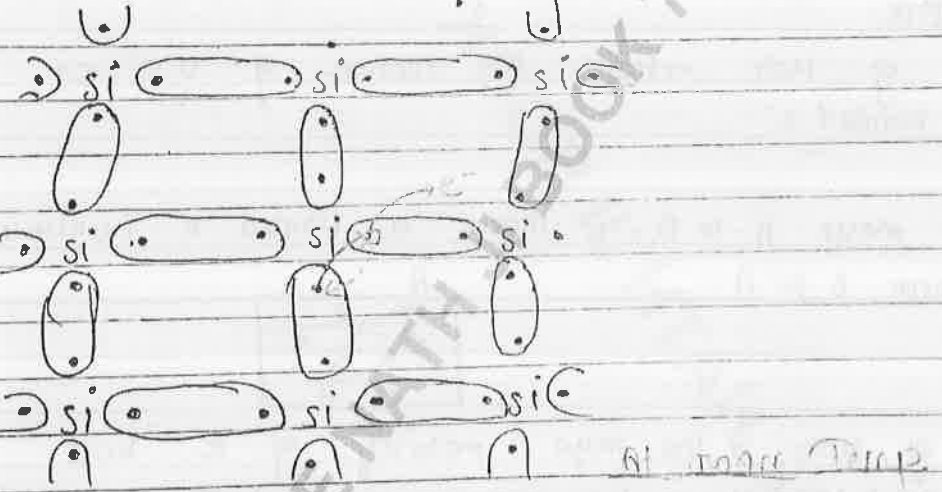
15/11/16

GENRAL PROPERTIES OF SEMICONDUCTOR – (Si or Ge)

① Tetravalent
② Crystal line structure (F.C.C.)
③ Covalent bond b/w atoms
④ Two types of charge carrier $e^-$ & Hole.
⑤ $\alpha$ = -ve Temp ↑ R ↓ $\sigma$ ↑
⑥ ON adding impurity its conductivity ↑se

Types of semiconductor –

(1) INTRINSIC SEMICONDUCTOR → / PURE semiconductor →

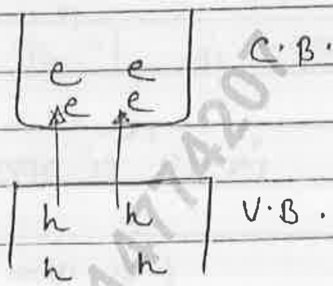



⇒ At room temp some bonded $e^-$s which have suffient amount of Thermal energy (KE) to overcome the ionisation energy of Si atoms are free from Si atoms.

⇒ When 1 Si atom ionise then we say 1 covalent bond break in crystal & 1 $e^-$ & Hole are produce in pair.

⇒ in (intrinsic) semiconductor charge carrier are produce only due to breaking of covalent bond. due to thermal energy. so its (conductivity) depends only on (Temp).

⇒ ENERGY LEVEL DIAGRAM ⇒




↳ for Si
so $\Delta E_g = 1.12$
↳ no of $e^-$ = no of h (always)

⇒ in intrinsic S.C. $n_e = n_h = n_i$

Here $n_e$ = $e^-$ density / $e^-$ conc / $e^-$ per unit vol.
$n_h$ = Hole density / Hole conc / Hole " "
$n_i$ = $e^-$ hole pair density.
(or)
charge carrier conc. in intrinsic S.C.

Total charge carrier conc = $n_e + n_h$
$= n_i + n_i$
$= 2n_i$

⇒ at Temp T K, no of $e^-$ move from VB to C.B. is ⇒

$$n = A T^{3/2} \cdot e^{-\frac{\Delta E_g}{2KT}}$$

(A = const.)
(K = Boltzman const)

① if Temp = const

$$\{ n \propto e^{-\Delta E_g} \}$$

$\Delta E_g$ ↓se, $n$ ↑se

LD in a S.C

(ii) if $\Delta E_g$ = const $n \propto T^{3/2} e^{-1/T}$ — T↑ n↑

(iii) Si atom density = $5 \times 10^{28}$ atom/$m^3$

at room temp — in $10^{12}$ Si atoms, 1 $e^-$ becomes free.

in $10^{12}$ Si atom ⇒ free $e^-$ = 1

1 Si atom = $\frac{1}{10^{12}}$

$5 \times 10^{28} = \frac{1}{10^{12}} \times 5 \times 10^{28}$

$= 5 \times 10^{16} \simeq 10^{16}\ m^{-3}$

in silicon, $e^-$ conc ($n_e$) $= n_h = n_i = 10^{16}\ m^{-3}$

(iv) Ge atom density = $4 \times 10^{28}$ atom/$m^3$

at room temp → in $10^{9}$ Ge atom 1 $e^-$ becomes free.

~~in 10~~

in Ge $n_{e^-} = n_h = n_i = 10^{19}\ m^{-3}$

⇒ $\sigma = ne\mu$ → at room temp if no of charge carrier $10^3$ then
($\sigma \propto n$) conductivity also $10^3$.

$\frac{\sigma_{Ge}}{\sigma_{Si}} = \frac{10^{19}}{10^{16}} = 10^3$

[B] In conductor $n_c = 10^{28}\ m^{-3}$

$10^{19} <<< 10^{28}$

⇒ at room temp, charge carrier is in intrinsic S.C. are negligible compare to conductor, so practically S.C. does not use as a conductor.

⇒ (To ↑se conductivity), we (add impurity).
↳ (bcoz of ↑ in no of charge carrier ↑)

[B] EXTRINSIC SEMICONDUCTOR / DOPPED S.C → ~~Adding~~ Addition of impurity c/d doping.

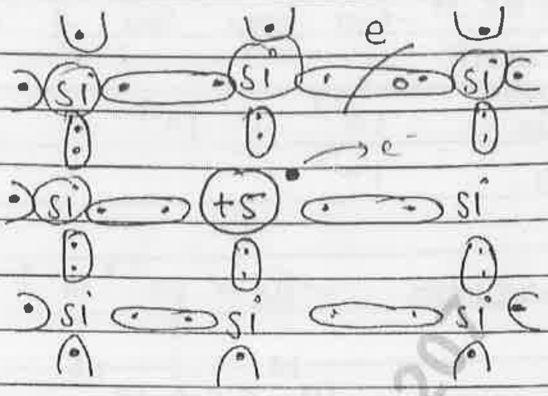
(2) Doping ratio $10^6$ si : 1 atom impurity to $10^8$ si : 1 atom impurity.
dopped dopped

(3) Intrinsic S.C. + impurity = Extrinsic.
Si or Ge

pentavalent ($P, As, Sb$) → max val = +5
⇒ N-type

Trivalent → max val +3
B, Al, Ga, In
⇒ P type.

(ii) N-type SC →




⇒ At room temp, impurity atom donate its a $5^{th}$ $e^-$ in crystal to gain stability. so Here impurity k/a a donar impurity.

⇒ After donate $1e^-$, impurity atom becomes ⊕ve imobile ion.

⇒ Majority charge carrier = $e^-$

⇒ Minority charge carrier = Hole.

⇒ $10^6$ Si atom — 1 impurity atom = 1 (donate)

$5 \times 10^{28}$ atom/$m^3$

impurity density $= \frac{1}{10^6} \times 5 \times 10^{28}$

$= 5 \times 10^{22}$

$\simeq 10^{22}$

↳ total calculation nhi… just for us

⇒ $e^-$ density →

$n_e$ = impurity density + Temp

$= 10^{22} + 10^{16}$

$= 10^{16}(10^6 + 1)$

$\simeq 10^{22}$

↳ Here $(10^{16} \lll 10^{22})$ (Temp, impurity)

✱ $n_e$ ≃ donar impurity density ($N_D$)

$\{n_e = N_D\}$